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The Magnolia Warbler *Dendroica magnolia* on Unaka Mountain, Unicoi County, TN: Possible Breeding and Habitat Analysis.

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The Magnolia Warbler *Dendroica magnolia* on Unaka Mountain, Unicoi County, TN:

Possible Breeding and Habitat Analysis

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by

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ABSTRACT

The Magnolia Warbler *Dendroica magnolia* on Unaka Mountain, Unicoi County, TN: Possible Breeding and Habitat Analysis

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The chief purpose of this study is to provide information on the habitat and breeding information of Magnolia Warblers on Unaka Mountain. Magnolia Warblers breed in Canada and the Northeastern United States. There are no current breeding records for this species in Tennessee.

For the habitat analysis, trees were identified on individual subplots. Shrubs were analyzed using the point-intercept method. Most of the major tree and shrub species were different from those found in Maine, which is a major breeding region for this species. Therefore, it's the structure of the habitat that is important for nesting. Fledglings were seen, giving solid proof of breeding.

This study is important because it provides proof of a new breeding bird in Tennessee and establishes habitat information necessary for its conservation.

ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION

The Magnolia Warbler (*Dendroica magnolia*) is common to the eastern boreal forest region of North America. It is a neotropical migrant that spends its summers in Canada and the northeastern United States and winters in the West Indies and Mexico and south to Panama (Bent 1963). It is, therefore, expected that in eastern Tennessee this species should only be present during times of migration between the breeding and wintering grounds. This bird is a medium-sized wood warbler measuring between 11 and 13 cm in length. During the breeding season, the male has a gray dorsal surface with a yellow rump. Its ventral surface is yellow and has heavy black stripes. The head is gray and is covered laterally with a black mask. This bird has heavy white wing bars. If the tail is observed from below, it is white medially but becomes black distally. A female in breeding season does not have the black face mask. Also its wing bars and ventral (breast) striping are much less conspicuous (Hall 1994).

My research focuses on a group of individuals that have been summer residents on Unaka Mountain (elevation 5,190 ft), situated on the border of Unicoi County, Tennessee and Mitchell County, North Carolina, although, the areas that were included in my research were all in Tennessee. The preferred habitat of this species in its summer breeding range is in and around coniferous areas. Enid Cumming (2002) found that Magnolias in Saskatchewan, which were living in a boreal mixedwood forest, reached the highest densities in areas that were very old stands, meaning that the stand was over 140 years old. Therefore, undisturbed forests are a great place to locate this species. They prefer the transition between coniferous and hardwood areas. It has been shown that an increase in the amount of coniferous trees in old stands will result in greater usage of that habitat by Magnolia Warblers (Hobson 2000). These birds like to have a densely-growing understory, also, and the only place in eastern Tennessee that this habitat can be found is at higher elevations (4,300 feet and above). They are often found in areas of dense understory with only a few sparse trees protruding through to serve as perches for males to sing from. This species has slowly been extending its breeding range southward along the Appalachian Mountains and is only found at these high elevations at the most southern latitudes. For my research I will determine which plants make up the tree and shrub layers for the Magnolia's habitat in the north and in its new southern extension of its breeding range. I will also be analyzing the structure of these habitats. I believe that the habitat in these two different locations will be similar in structure but will be made up of different species in different geographic locations. Part of my research will involve a habitat analysis of different plots on Unaka Mountain. The data from this research can then be compared to information that is already available on the habitat that can be found in the historical breeding range of this species.

There are early records (Cairns 1889) that suggest that the Magnolia Warbler did once nest in the Appalachian Mountains of North Carolina. This species was not found again in this area during the breeding season, however, until the 1980s. It is a common migrant in the spring in fall. There have been sightings of individuals in the mountains of northwestern North Carolina in recent years as stated in *The Chat*, the Carolina Ornithological Society's quarterly journal, but there has never been any proof of breeding, and these individuals are never seen consistently in the same area year after year as they have been on Unaka Mountain. Individuals were observed on Roan Mountain, North Carolina, on June 28 and July 1, 2000 (Davis 2001) and also again in 2003 on the Cloudland Trail section going to Roan High Bluff during the first week of June, but these are not seen every year, and no proof of breeding has ever been found. Magnolia Warblers have been seen during the breeding season each year for the last decade on Unaka Mountain. Rick Knight lists the Magnolia Warbler in his book that contains birds found in the northeastern Tennessee area (Knight 1994). From this information Unaka Mountain looks like the most likely place for Magnolias to be breeding in this area.

The main area of consideration for this study is the habitat that this species is using on Unaka Mountain and how it compares to other nesting sites in the southern Appalachians (Virginia and West Virginia) and to nesting sites in the northeastern United States, which is in its historical breeding range. A summer breeding range for this species is shown in Figure 1. Because this covers a large area with diverse habitats, I hypothesize that it is the structure of the habitat that is important, and not specific species that are present in the habitat. This species historically prefers areas of mixed hardwood and conifers species, such as a transition between these two forest types. It also prefers a dense understory associated with the forest. The only areas in the southern Appalachians that have a habitat similar to this are found at higher elevations where there is a transition between hardwood and conifer forests such as on Unaka Mountain. I hypothesize that the habitat on Unaka Mountain where Magnolia Warblers are found is similar in structure to the habitat just described. If this is shown to be true, then using this information, other habitats in the southern Appalachians that have this same general structure, which could serve as possible future Magnolia Warbler habitat, can be identified.

Another important aspect of this research is that if any solid breeding proof is found, then Unaka Mountain, TN represents a southern extension in the breeding range of the Magnolia Warbler. This species could be a new breeding bird for the state of Tennessee. If the habitat requirements for this species are thoroughly understood, then future conservation efforts to protect Magnolia Warbler habitat can be strengthened with the addition of this valuable Unaka Mountain habitat information.

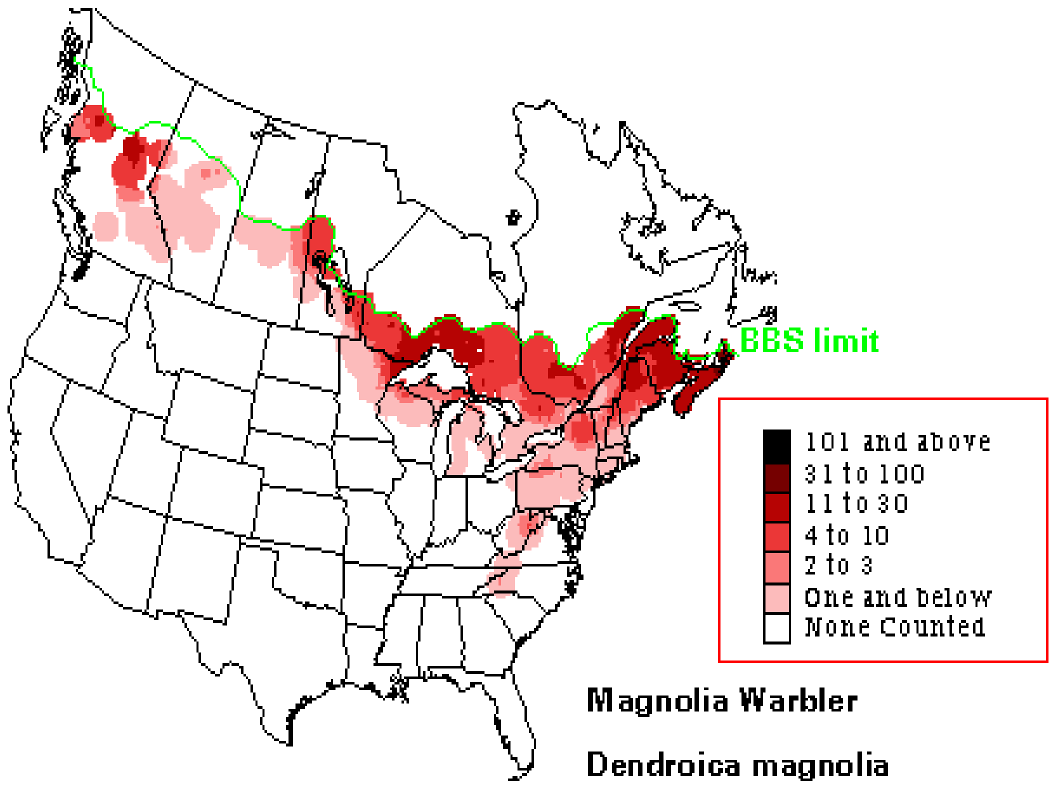

Figure 1 Breeding range of the Magnolia Warbler (*Dendroica magnolia)* in Canada and the northeastern United States (USGS 2002)

CHAPTER 2

METHODS AND MATERIALS

Migration Information

Magnolia Warblers leave their wintering areas in the West Indies and Mexico and south to Panama in late February or early March. They arrive on their breeding grounds in southern and mostly eastern Canada and the northeastern United States from mid-April to early May (see figure 1). They depart the breeding grounds in early to mid-August and arrive back in their neotropical wintering areas in late September or early October.

Nesting Behavior

The males are the first to arrive on the breeding grounds, followed by the females 7-10 days later. During this first week, the males establish personal territories in which they sing, attracting females. Courtship and mating then occur, and nest building starts about 2 weeks after the males arrive and takes between 4-6 days. The preferred types of trees to nest in are spruces, but hemlocks are also important as shown by Mitchell (1999). The nest is flimsy and cup-like, and it is usually built on a horizontal branch near the trunk of the tree (Chapman 1968). It is lined with black rootlets. The first egg is usually laid 1-2 days after the completion of the nest, and there are usually a total of 4 eggs laid. They are laid 1 egg per day until the clutch is complete. There is normally only 1 brood per season, but more eggs can be laid if the first nestlings are lost. The incubation time is usually between 11-13 days, and the young will leave the nest somewhere between 9 and

10 days later. Therefore, the best time to look for nests is from late May to early June in the southern Appalachians.

Foraging Behavior

Magnolia Warblers feed primarily on insects. They can be seen moving quickly from tree branch to tree branch taking insects that are on or around these branches. They stay largely on the outer edges of trees and rarely sit still when feeding but instead move quickly to find their prey. When the time of the year nears the fall, the weather begins to cool, and their food supply begins to disappear. The Magnolia warblers then migrate to the tropics where there is a plentiful food supply.

Research

My research will involve finding Magnolia Warbler territories on specific plots on Unaka Mountain. I will then observe their behavior and watch for any nesting behavior that I can detect. I will also be conducting a thorough habitat analysis of the areas that these birds are using. This information is very important in the conservation of this species. If any proof of breeding can be recorded, the Magnolia Warbler can be added to the list of Tennessee breeding birds, and Unaka Mountain would represent a southern extension in the breeding range of these species. If we understand the type of habitat that this species uses, then we will be better able to conserve other suitable habitat nearby where this bird could likely immigrate to sometime in the future.

Territory Location

The elevation of Unaka Mountain at its highest point is 5,190 feet above sea level. It is at these higher elevations that a suitable habitat for Magnolia Warblers can be found. This is where a transition can be seen between the Red Spruce (*Picea rubens*) and northern hardwood forest. Four plots have been selected as possible territories/breeding sites for these birds. They are Stamping Ground Ridge, Horseback Ridge, Pleasant Garden, and a site that has previously been used as a site for breeding bird surveys by the USDA Forest Service (figure 11). All of these sites have good habitat that includes both hardwood and conifer tree species and a dense understory, for the Magnolias and are areas where this species has been seen in the past.

Site number 1 is on Stamping Ground Ridge (Figure 2). It has a dense understory in most areas but with a few areas where the understory is more sparsely spread out. There are a few Table Mountain Pines (*Pinus pungens*) and large Red Spruces, which are very suitable trees for a Magnolia nest, can be found growing on this large plot. The terrain is somewhat rocky and is for the most part fairly level compared to the other plots. Magnolia Warblers have been observed on this plot in past summers. Figure 3 is another picture of Stamping Ground Ridge. Here the structure of the habitat is very clear. There are many shrubs with sparse trees (including Red Spruce).

Figure 2 Red Spruce on Stamping Ground Ridge

Figure 3 Blueberries and Rhododendron on Stamping Ground Ridge

Site number 2 is on Horseback Ridge (Figures 4 and 5), which has a very similar flora makeup compared to Stamping Ground Ridge. The terrain is very rocky, and the elevation falls here quite quickly. Several large Eastern Hemlocks (*Tsuga canadensis)*, Red Spruces, and Table Mountain Pines can be found here, as is seen in the picures. Red Spruce trees can often be seen protruding from the shrub layer. Magnolia Warblers have been found here also in past breeding seasons.

Figure 4 Eastern Hemlock and Red Spruce in the Background on Horseback Ridge

Figure 5 Rhododendrons in the Foreground on Horseback Ridge

Site number 3 is the plot that has been used as a breeding bird survey plot for the last few years. In the summer of 2000, Allan Trently (Lewis 2000), who was conducting the survey, saw fledglings on the ground with an adult Magnolia. There is a very high probability that these were Magnolia fledglings, establishing this as another good location to look for these birds. Mr. Trently showed me around the BBS plot and where the fledglings were seen (Trenly 2003). This plot is fairly steep and is located on the edge of the Red Spruce forest. The upper part of the plot is completely dominated by this species (Figure 6). The lower part becomes a mix of Red Spruce and hardwoods. In Figures 7 and 8 Rhododendrons can be seen in the understory, with some Red Spruce in the distance.

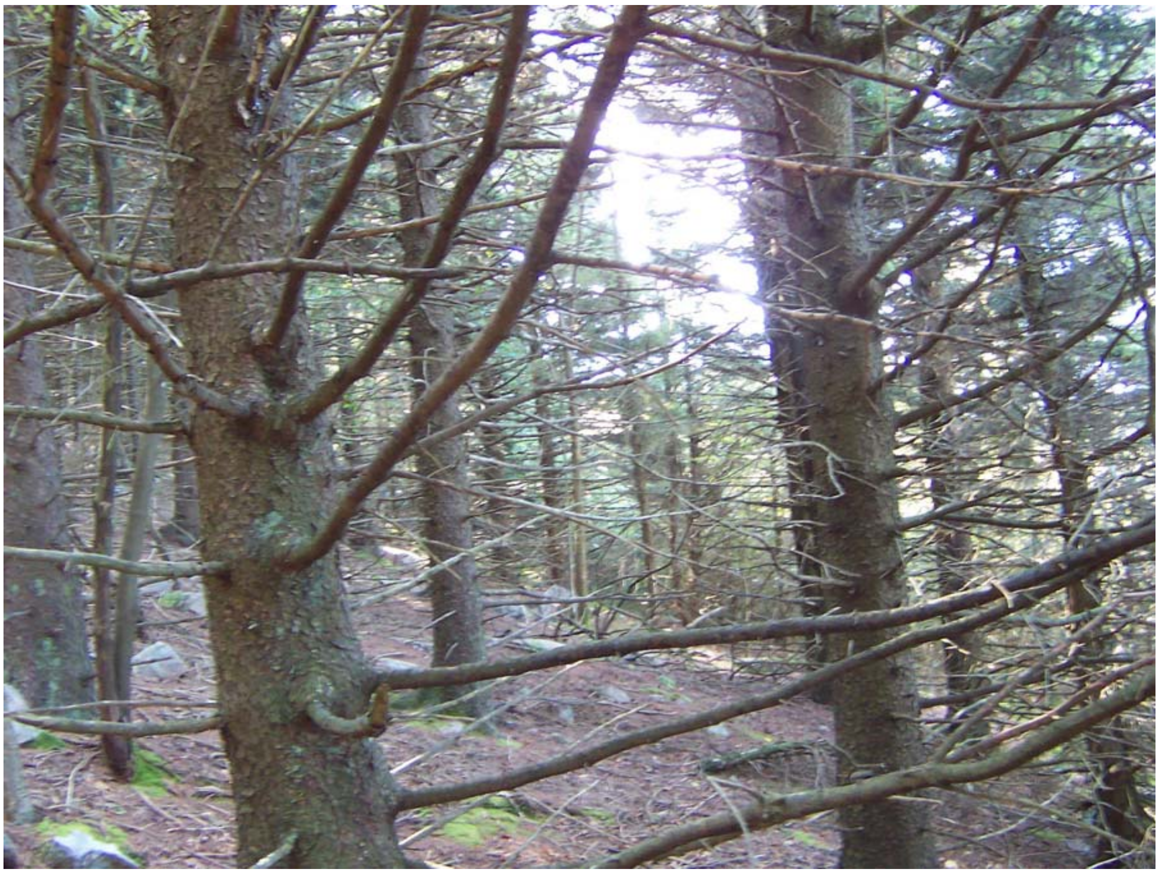

Figure 6 Red Spruce Forest at Highest Elevations of the BBS Plot

Figure 7 Rhododendrons in Understory on the BBS Plot

Figure 8 Rhododendrons, Red Spruce, and Hardwoods on the BBS Plot

Site number 4 is on Pleasant Garden. Parts of this plot are steep. There is a parking lot here with a good view over the trees down the side of the ridge, and there are also some more thickly wooded areas with large spruce and hemlock trees. Magnolia Warblers have been seen in the past on this plot but not for the last few years. In Figure 9 Several large Eastern Hemlocks and Red Spruces can be seen. The dense Rhododendrons can be seen in Figure 10.

Figure 9 Eastern Hemlock and Red Spruce on the Pleasant Garden Plot

Figure 10 Dense Rhododendrons with a Large Red Spruce on the Pleasant Garden Plot

All of these plots are areas where Magnolia Warblers have been seen in the past. Each plot has both hardwood and conifer species present. Red Spruce and Eastern Hemlock, which are tree species that the Magnolia Warbler is known to nest in, are fairly common on Unaka Mountain, with the higher elevations being covered by a Red Spruce forest. All of the plots have a thick understory layer of shrubs and young trees. All of these factors lead to the conclusion that these plots contain habitat that is well suited for the Magnolia Warbler.

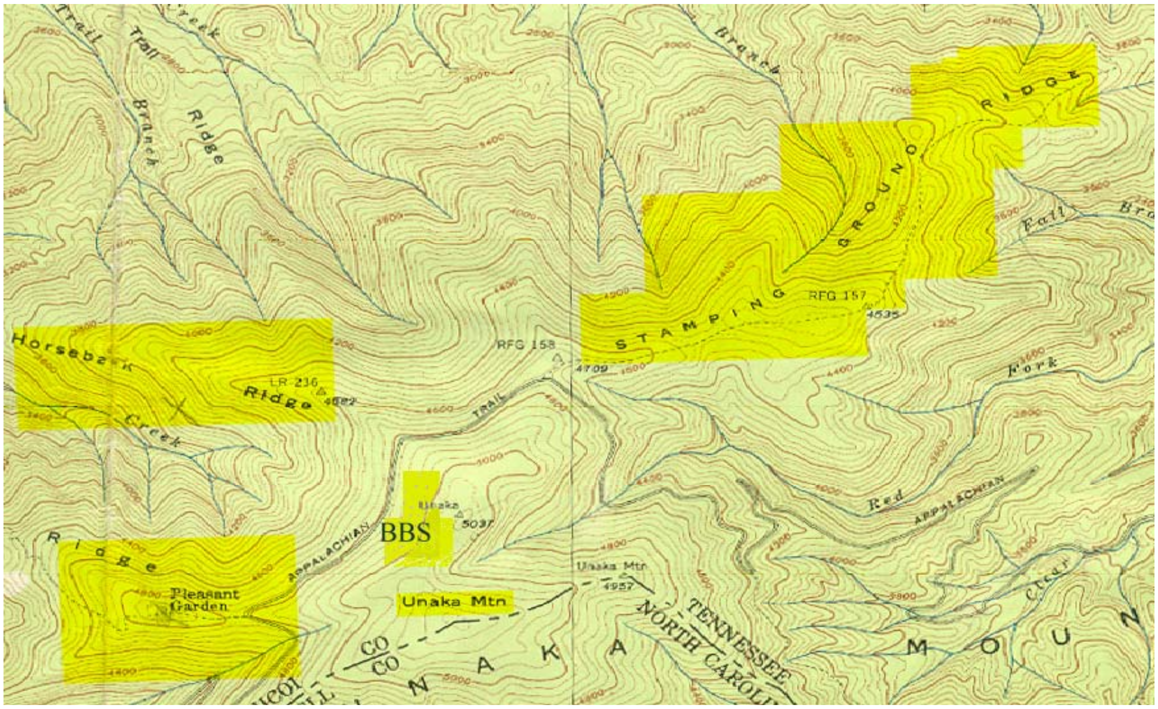

Figure 11 Location of Stamping Ground Ridge, Horseback Ridge, BBS, and Pleasant Garden on Unaka Mountain (Unicoi quadrangle 1939)

Habitat Analysis

For my research I selected two methods for habitat analysis, used by Matsuoka while looking at breeding birds in Alaska (2001). I propose to analyze both the tree layer and the understory, or shrub layer. For this study a tree is considered any plant with a woody stem that has a diameter at breast height (DBH) of 5 cm or greater. A shrub is any plant with a woody stem that has a DBH of less than 5 cm. This means that small, young trees can be included in this "shrub" layer because they are found in the lower growing understory.

To measure and describe the tree layer, three subplots in each main plot are randomly picked. These subplots each measure 20 meters x 20 meters. In each subplot every tree found that is over 5 cm DBH (diameter at breast height) was recorded. I identified each tree species and recorded its DBH. This method provided an average of the dominant species present and the average size tree for each species for each plot using these sample subplots.

To analyze the shrub layer the point intercept method was used. This method was applied to the same 20 meters x 20 meters subplots used for the tree data. Three 20 meter long lines are measured across the subplots. They are parallel to one another and are 6 feet apart. The middle line goes through the middle of the plot, and the other 2 lines are located 1 on each side of the middle line. On each line, starting at the beginning of the line, every woody plant in the shrub layer was identified 1 meter at a time. The highest point this shrub attains at that specific point was also recorded. A 3 foot long dowel rod with a 1 inch diameter is held perpendicular to each point starting at the ground, and any shrub that intersects this rod will be recorded. This takes place at 1 meter intervals.

Therefore, each line has 20 points of data, and each plot consists of 60 points of data. This method provides information about which shrubs are the dominant shrubs, and it gives information about the average height of each species in each plot.

Statistical Analysis

To compare the 4 plots, hierarchical cluster analysis has been chosen. This statistical method is used to rind fairly homogenous clusters of certain cases based on characteristics which have been measured. Each case begins in a separate cluster, with clusters combining sequentially, reducing the number of clusters until there is only one remaining. The hierarchical clustering process can be represented as a dendrogram, or a tree. This dendrogram gives a visual example of how the different plots are related to one another. The clustering method chosen for this analysis is the centroid method. The centroid of each cluster is simply its average point in a multidimensional space. It can be seen as the center of gravity for a cluster. Therefore, the distance between 2 clusters is simply the difference between centroids. This is a good method for this type of analysis because it takes a sort of average of all of the measurements. For the dissimilarity matrix, a squared Euclidean distance is used, which is commonly used for this type of analysis. This basically is a straight line distance between the observations in space. The larger the number for each comparison between plots, the less related they are to each other. The following measurements were used for the analysis: the number of large woody plants on each plot, the average DBH of these large woody plants, the average height of the small woody plants for each plot, the percentage of young trees that were small enough to be included with the small woody plants, the percentage of Red Spruce in the large woody plant layer, the percentage of Red Spruce in the small woody plant layer, and the total number of small woody plants recorded for each plot (this includes number of small woody plants recorded for each meter, which can involve the same plant being counted more than once if it covers a large amount of space).

CHAPTER 3

RESULTS

Individual Plot Results

The large woody plants and small woody plants on the 4 plots were surveyed. The large woody plants (greater than or equal to 5 cm DBH) were identified to species, and the diameter at breast height (DBH) was determined for each. The small woody plants (less than 5 cm DBH) were also identified, and the height of each was determined. All of the measurements are in centimeters. The error bars on the graphs represent the standard error of the mean. The tables that list the results for this section are located in the appendix. Tables 4 – 15 contain the results for the Stamping Ground Ridge plots. Tables 16 – 27 show the results for the Horseback Ridge plots. The BBS plots results are found in Tables 28 – 39. And the results for the Pleasant Garden plots are found in Tables 40 – 51.

The first comparison to be made is for species frequency for the large woody plants. Stamping Ground Ridge (figure 12) had 7 species present (2 of these are evergreens), with Sourwood having the highest frequency at 32% followed by Fire Cherry and Table Mountain Pine at 18%. Horseback Ridge (figure 13) had 9 species present (4 of these are evergreens), with Yellow Birch having the highest frequency at 26.7% followed by Eastern Hemlock and Red Maple at 16.7%. The BBS plot (figure 14) had 10 species present, 4 of which are evergreen species. Yellow Birch had the highest frequency at 22.3% and Sourwood follows at 18.1%. This plot had the oldest growth Rhododendron of any of the plots. They made up 12.8% of the total large woody plants here. The final plot was on Pleasant Garden (figure 15) which had a total of 12 species present, of which 3 are evergreens. When all 4 plots are considered together, Yellow Birch had the highest frequency at 74.6%, followed by Moosewood and Red Maple at 5.6%. This plot has several species present, but Yellow Birch is the only one present at greater than 10% frequency, so the large woody plants on this plot are not characterized by much evenness. The evergreen species are indicated by an "*".

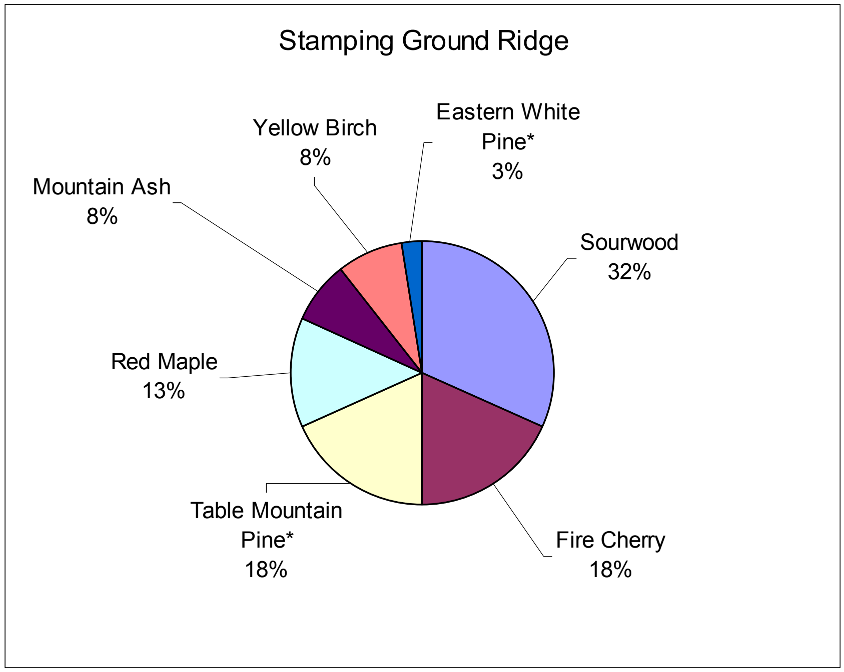

Figure 12 Graph Showing Large Woody Plant Species Frequency for Stamping Ground Ridge Plots

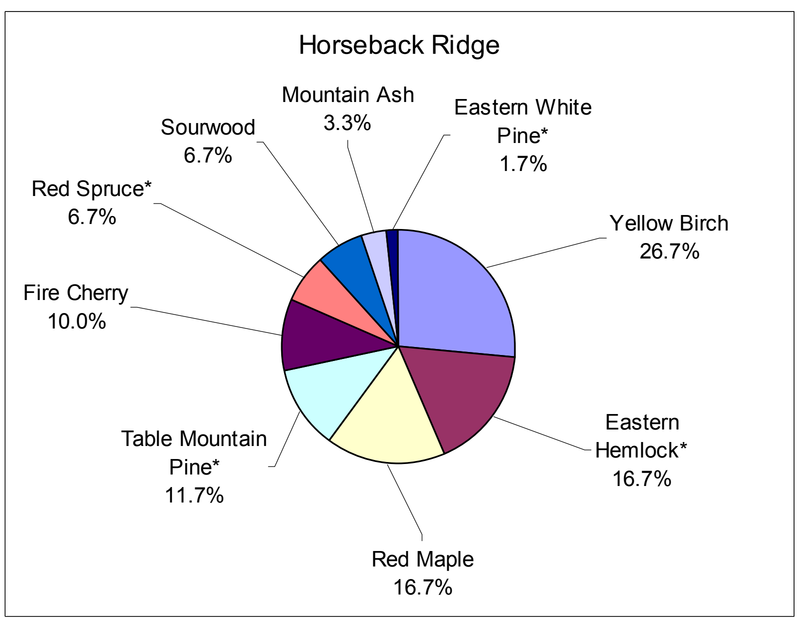

Figure 13 Graph Showing Large Woody Plant Species Frequency for Horseback Ridge Plots

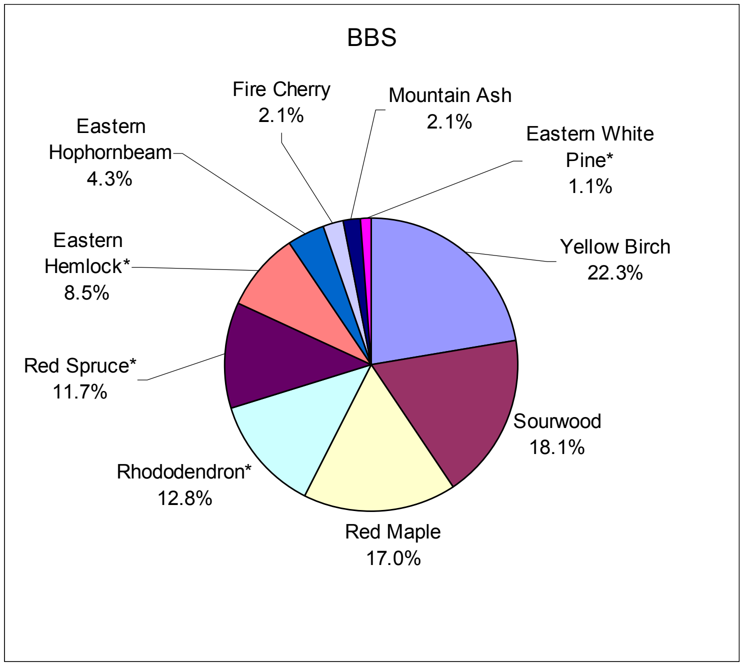

Figure 14 Graph Showing Large Woody Plant Species Frequency for BBS Plots

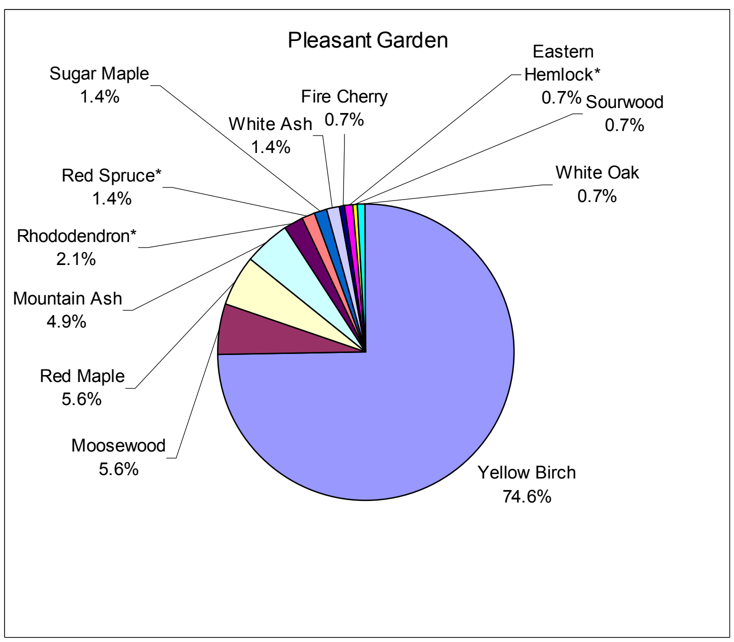

Figure 15 Graph Showing Large Woody Plant Species Frequency for Pleasant Garden Plots

The second comparison to be considered is the average DBH of the large woody plants. On the Stamping Ground Ridge plots (Figure 16), Table Mountain Pines averaged the largest DBH at 12.3 cm. On the Horseback Ridge plots (Figure 17) Red Spruce had the highest average DBH at 17.7 cm. Eastern White Pines had the highest DBH on the BBS plots (Figure 18). On the Pleasant Garden plots (Figure 19), Sugar Maples had the highest DBH at 19.9cm. The BBS plots had the most species with an average DBH of greater than 10 cm, with a total of 7 species. Three of these were evergreen species and 4 were deciduous. The Pleasant Garden plots were second with 6 species, 2 of which were evergreen species. The Horseback Ridge plots had 4 species with a DBH of greater than 10 cm, 3 of which were evergreen, and the Stamping Ground Ridge Plots had only 1 species of this size, which was an evergreen species. Therefore, the BBS and Pleasant Garden plots have more old-growth tree species present.

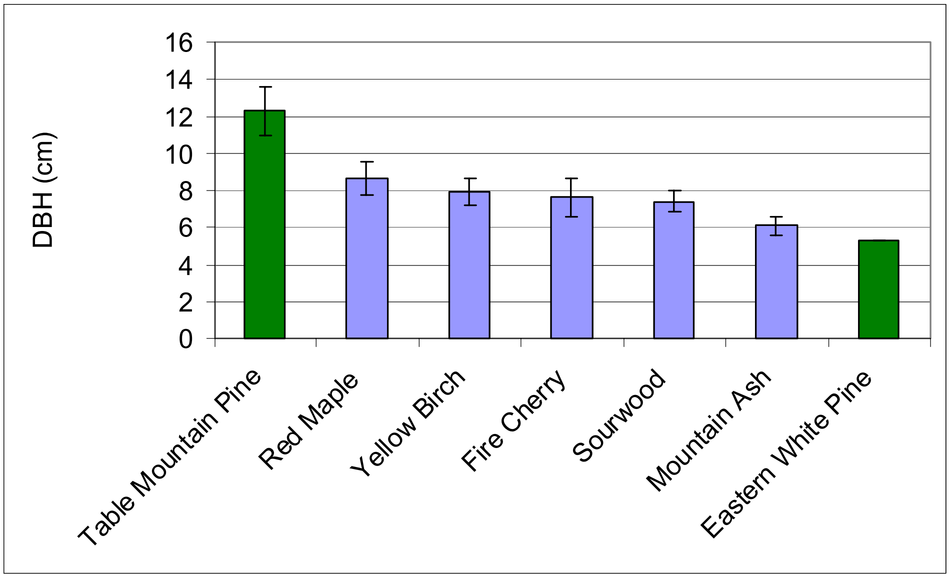

Figure 16 Graph Showing Average Large Woody Plant Species DBH for Stamping Ground Ridge Plots (Evergreen Species in Green)

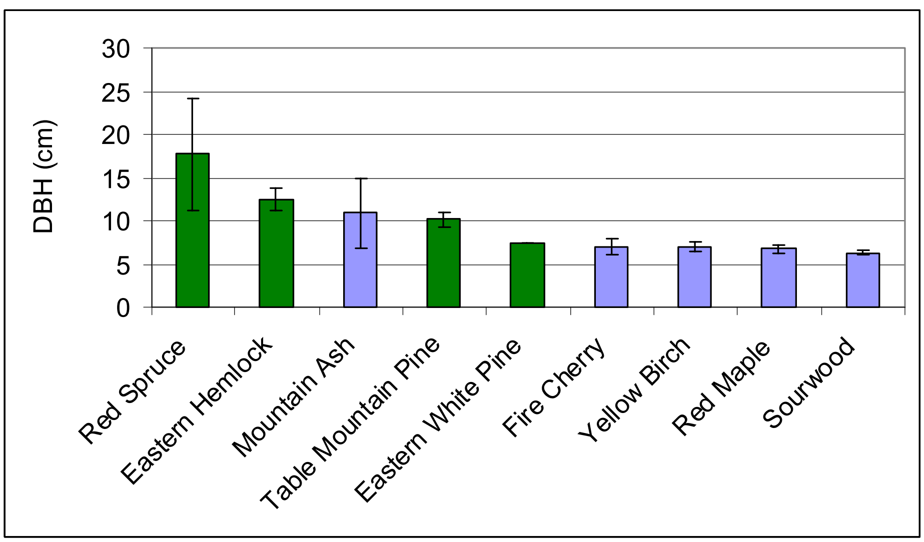

Figure 17 Graph Showing Average Large Woody Plant Species DBH for Horseback Ridge Plots (Evergreen Species in Green)

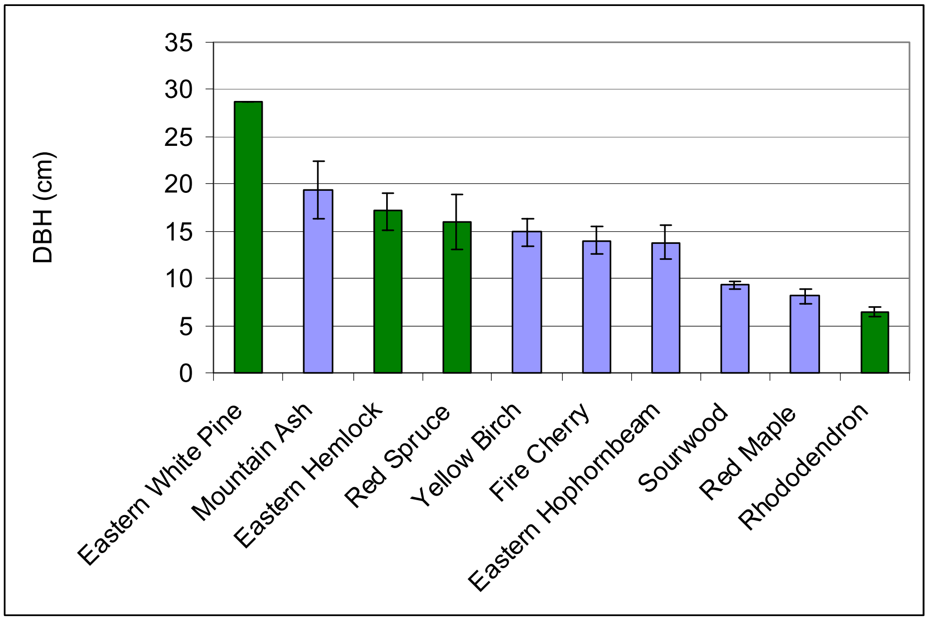

Figure 18 Graph Showing Average Large Woody Plant Species DBH for BBS Plots

(Evergreen Species in Green)

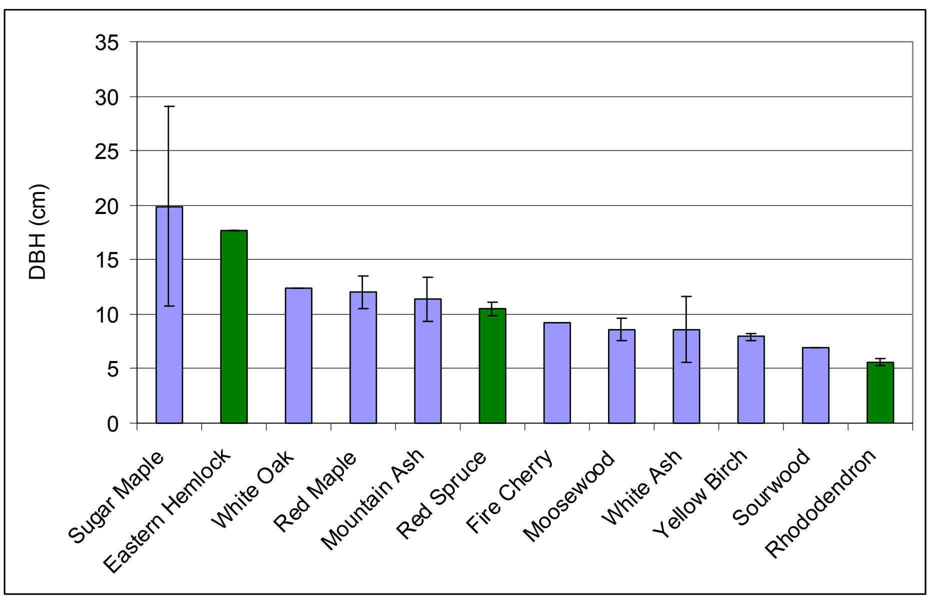

Figure 19 Graph Showing Average Large Woody Plant Species DBH for Pleasant

Garden Plots (Evergreen Species in Green)

The next area of comparison for the plots is the species frequency for the small woody plants. On Stamping Ground Ridge (Figure 20), there were a total of 9 species present, 3 of which were evergreens. Rhododendron was the most common at 44.4% followed by Highbush Blueberry at 26.4%. The Horseback Ridge plots (Figure 21) had a total of 11 species present, of which 4 were evergreens. Rhododendron was the most common at 55.8%, followed by Highbush Blueberry at 15.0%. There were a total of 6 species present on the BBS plots (Figure 22), and 3 of these were evergreen species. Rhododendron was the most common at 52.9%, followed by Highbush Blueberry at 22.7%. The final plot to consider is Pleasant Garden (Figure 23). There were 11 species present here, of which 4 were evergreens. Rhododendron was the most common at 57.7%, followed by Yellow Birch at 14.9%. This shows that there are many juvenile Yellow Birches regenerating on this plot. Tree species that were small enough to be counted in the small woody plant survey are denoted by a "+", and evergreen species are indicated by an "*".

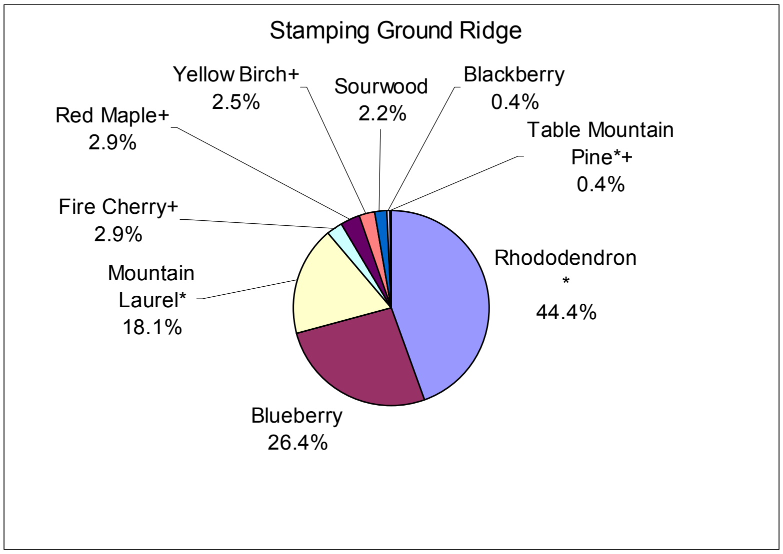

Figure 20 Graph Showing Small Woody Plant Species Frequency for Stamping Ground Ridge Plots

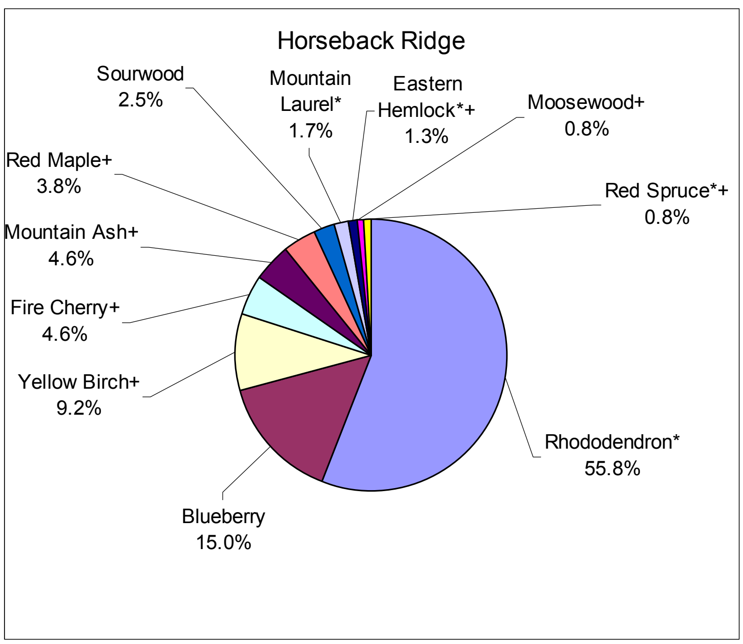

Figure 21 Graph Showing Small Woody Plant Species Frequency for Horseback Ridge Plots

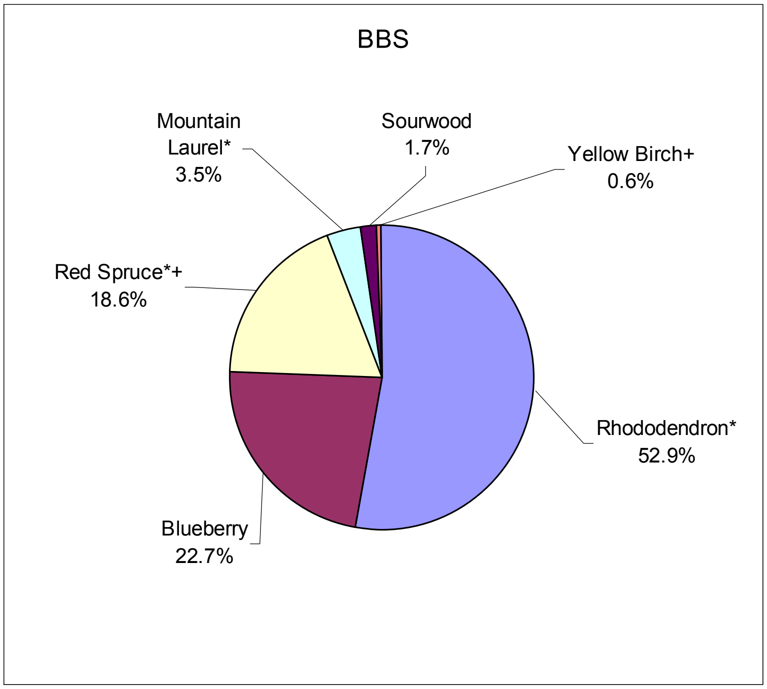

Figure 22 Graph Showing Small Woody Plant Species Frequency for BBS Plots

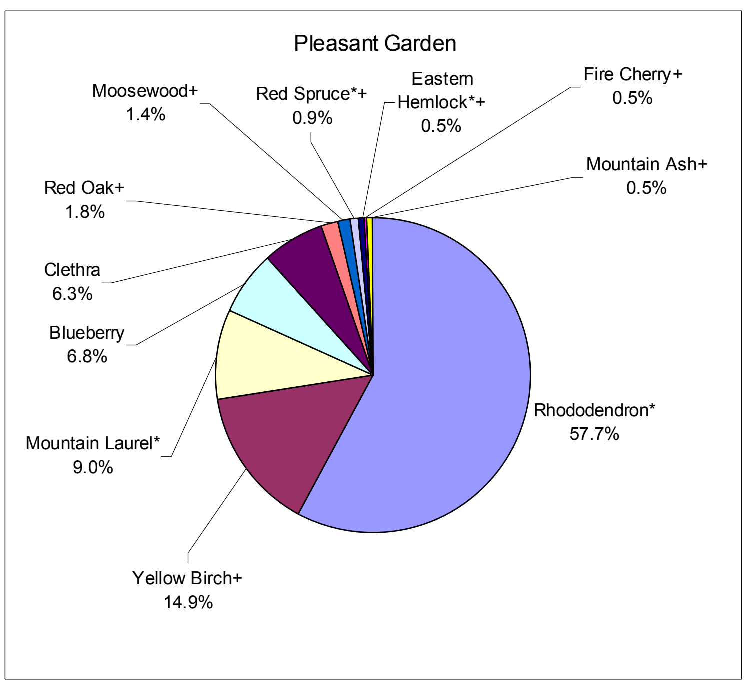

Figure 23 Graph Showing Small Woody Plant Species Frequency for Pleasant Garden Plots

The next area of comparison between the plots is the average height of the small woody plants. On the Stamping Ground Ridge plots (Figure 24), Yellow Birch was on average the tallest at 273.8cm. This was a tree species regenerating in the understory. On the Horseback Ridge plots (Figure 25), the Red Maples were the highest at 232.1cm. These were also tree species. The BBS plots were next (Figure 26) with the tallest species being Yellow Birch (tree species) at 322.7cm. On the Pleasant Garden plots (Figure 27) the tallest species was Mountain Ash (tree species) at 259.3cm. The tree species are denoted by a "+".

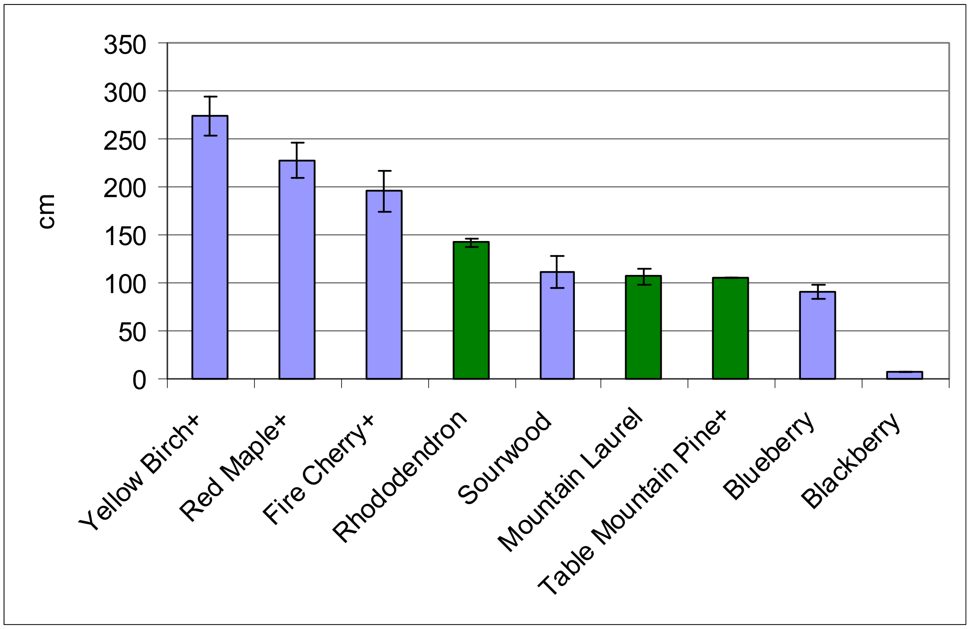

Figure 24 Graph Showing Average Height for Small Woody Plant Species for Stamping Ground Ridge Plots (Evergreen Species in Green)

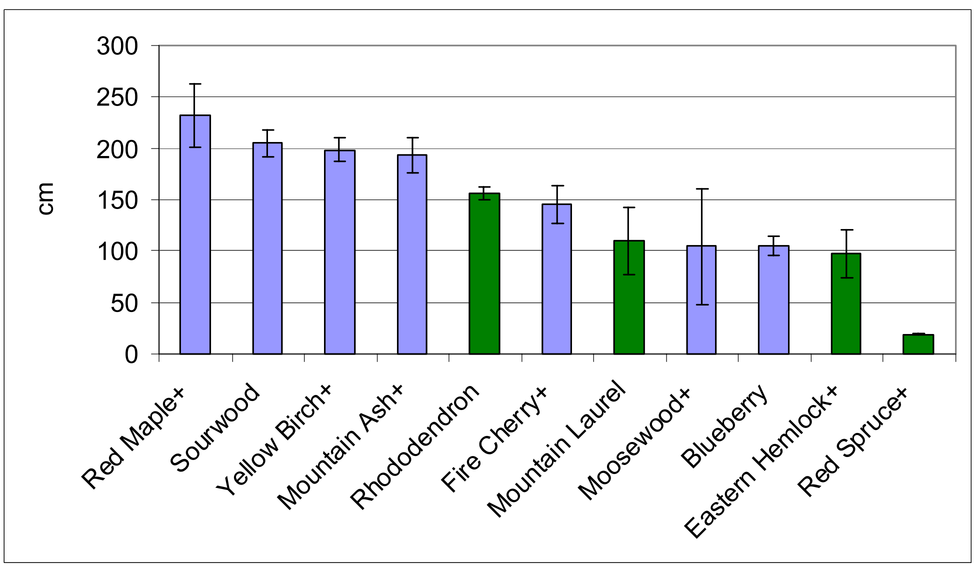

Figure 25 Graph Showing Average Height for Small Woody Plant Species for Horseback Ridge Plots (Evergreen Species in Green)

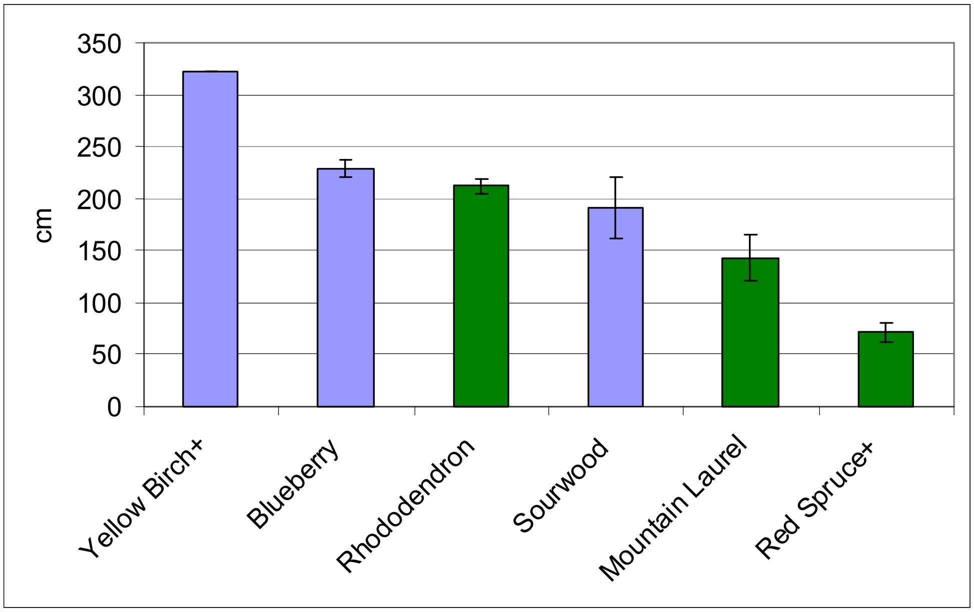

Figure 26 Graph Showing Average Height for Small Woody Plant Species for BBS Plots (Evergreen Species in Green)

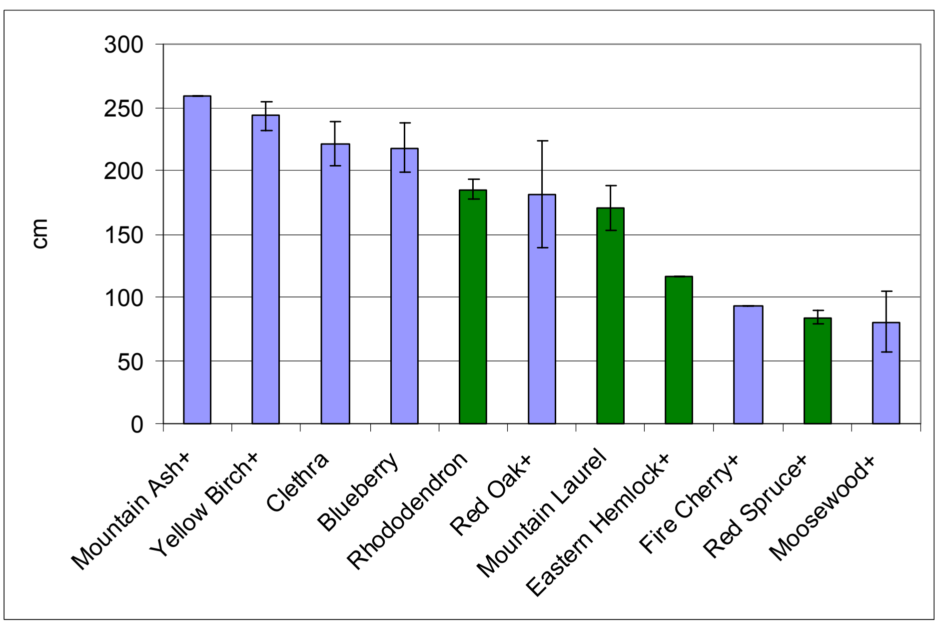

Figure 27 Graph Showing Average Height for Small Woody Plant Species for Pleasant Garden Plots (Evergreen Species in Green)

Territory Summary

After analyzing the data, the most common large woody plants present on the 4 plots on Unaka Mountain were Yellow Birch, which was the most common at 43.7%, followed by Red Maple at 11.7%, and then Sourwood at 10.2% (figure 28), all of which were found on each plot. The frequency of each species found on each plot is represented by percentages in Table 1. There were more large woody plants on Pleasant Garden (142) than on any other plot (Figure 29). Figure 30 shows the average large woody plant DBH for each plot. BBS has a significantly higher DBH (11.6) than the other plots. A plot showing average DBH vs number of large woody plants for each plot is found in Figure 31.

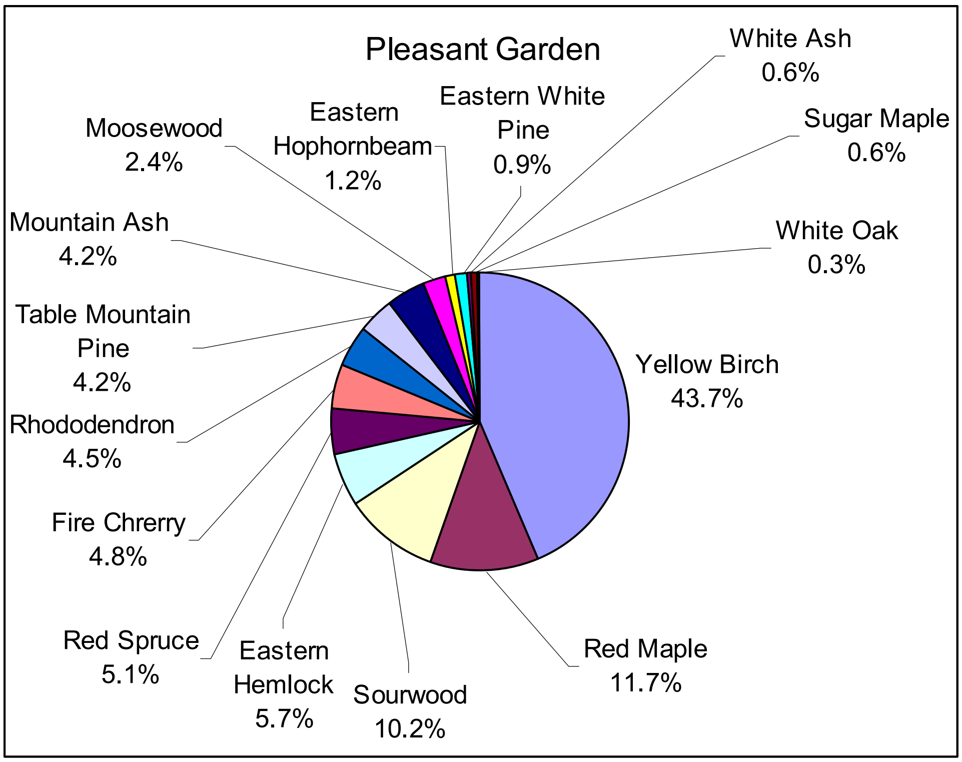

Figure 28 Graph Showing Large Woody Plant Species Frequency for all Plots

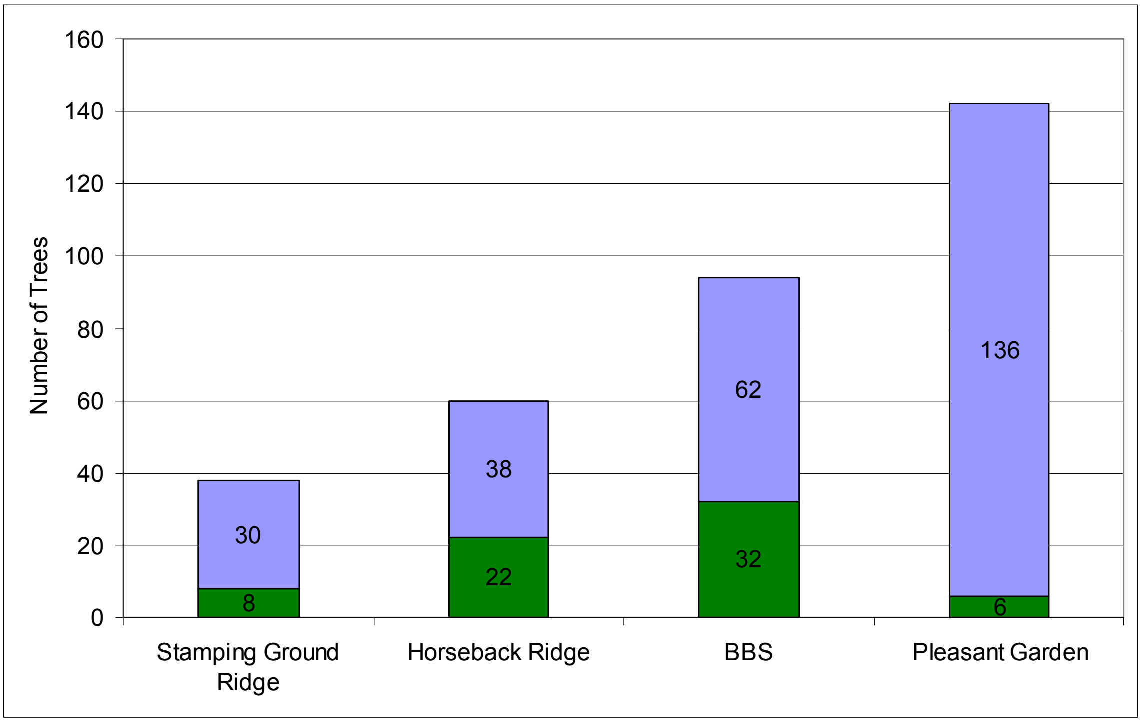

Figure 29 Graph Showing Number of Large Woody Plants on each Plot (Number of Evergreen Species in Green)

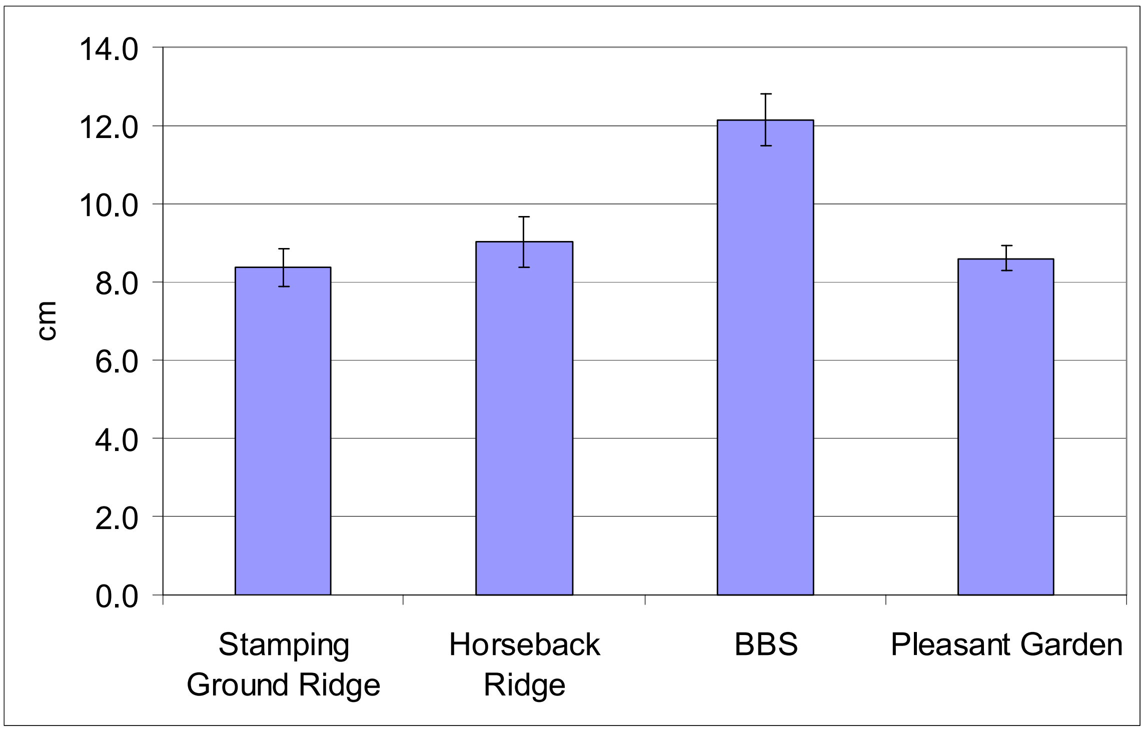

Figure 30 Graph Showing Average DBH of Large Woody Plants on each Plot

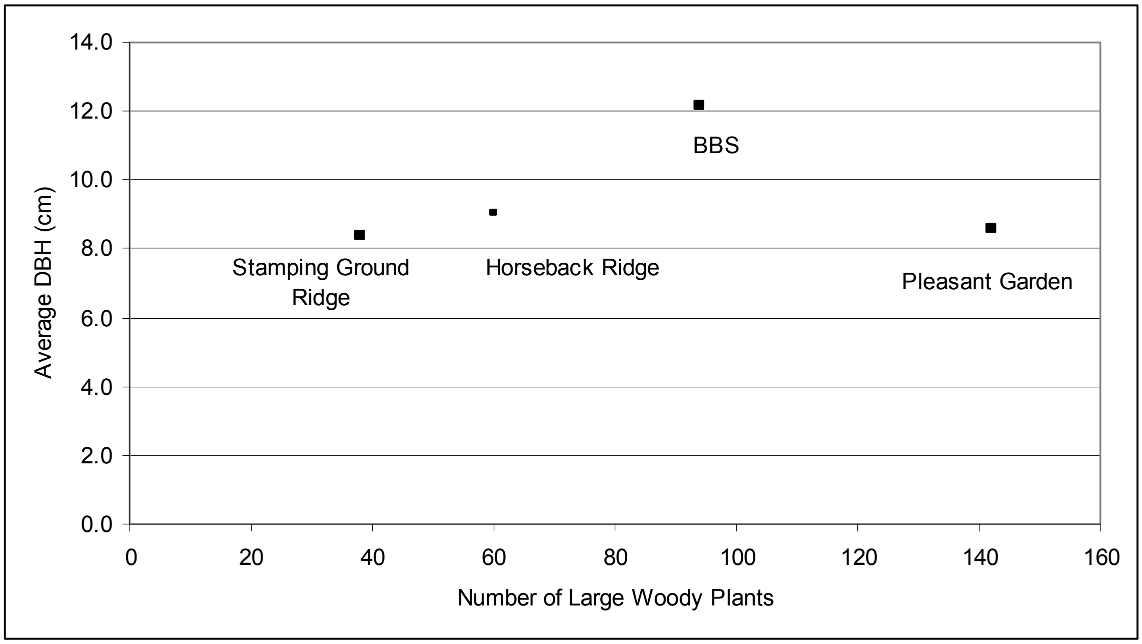

Figure 31 Graph Showing Average DBH vs. Number of Trees for Large Woody Plants on each Plot

Table 1 Large Woody Plant Species Frequency Summary of all the Plots

Species	Stamping Ground Ridge	Horseback Ridge	BBS	Pleasant Garden
Deciduous Species				
Mountain Ash	7.9%	3.3%	2.1%	4.9%
Red Maple	13.2%	16.7%	17.0%	5.6%
Yellow Birch	7.9%	26.7%	22.3%	74.6%
Fire Cherry	18.4%	10.0%	2.1%	0.7%
Sourwood	31.6%	6.7%	18.1%	0.7%
Eastern Hophornbeam	______	______	4.2%	______
White Ash	______	______	______	1.4%
Moosewood	______	______	______	5.6%
Sugar Maple	______	______	______	1.4%
White Oak	______	______	______	0.7%
Totals	79.0%	63.4%	65.8%	95.6%
Evergreen Species				
Table Mountain Pine	18.4%	11.7%	______	______
Eastern White Pine	2.6%	1.7%	1.1%	______
Eastern Hemlock	______	16.7%	8.5%	0.7%
Red Spruce	______	6.7%	11.7%	1.4%
Rhododendron	______	______	12.8%	2.1%
Totals	21.0%	36.8%	34.1%	4.2%

The most common small woody plants on the 4 Unaka Mountain Plots were Rhododendron (this includes both Rosebay and Catawba species) at 52.3%, Blueberry at 17.9%, Mountain Laurel at 8.8%, and Yellow Birch at 6.9%, all of which were found on each plot (figure 32). The frequency of understory plants found on each plot is represented by percentages in table 2. Figure 33 shows the average small woody plant heights for each plot. Figure 34 shows the total number of small woody plant measurements that were made for each of the plots. Because the measurements were made one meter at a time, then a larger small woody plant could be counted more than once if it overlapped the 1 meter areas. This measurement is to give a comparison of understory cover between the plots. Figure 35 shows the percentage of these small woody plants that are actually regenerating tree species that are small enough to be included with the other small woody plants.

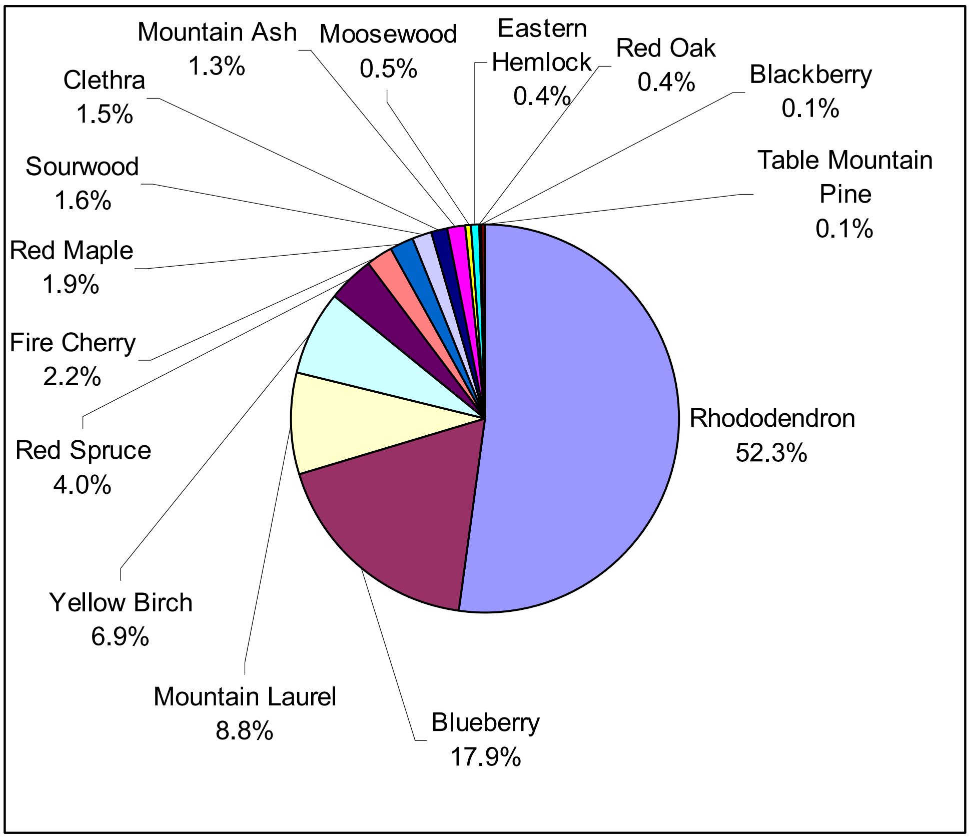

Figure 32 Graph Showing Small Woody Plant Species Frequency for all Plots

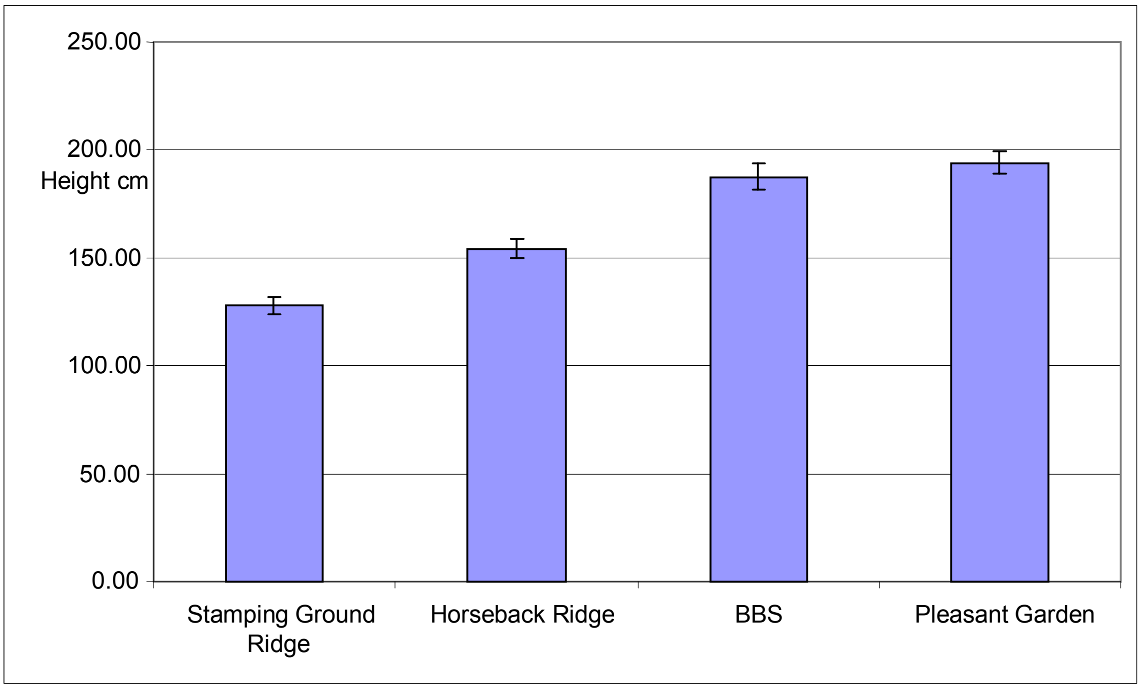

Figure 33 Graph Showing Average Height for Small Woody Plant Species for each Plot

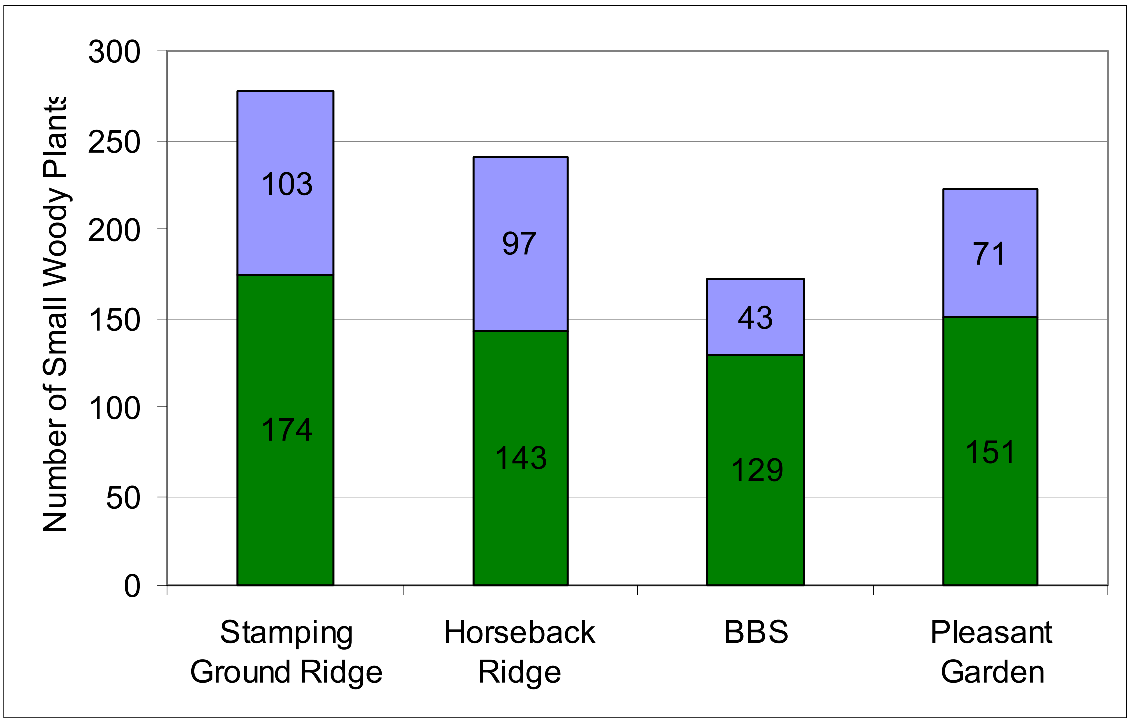

Figure 34 Graph Showing Total Number of Small Woody Plants on all Plots (Evergreen Species in Green)

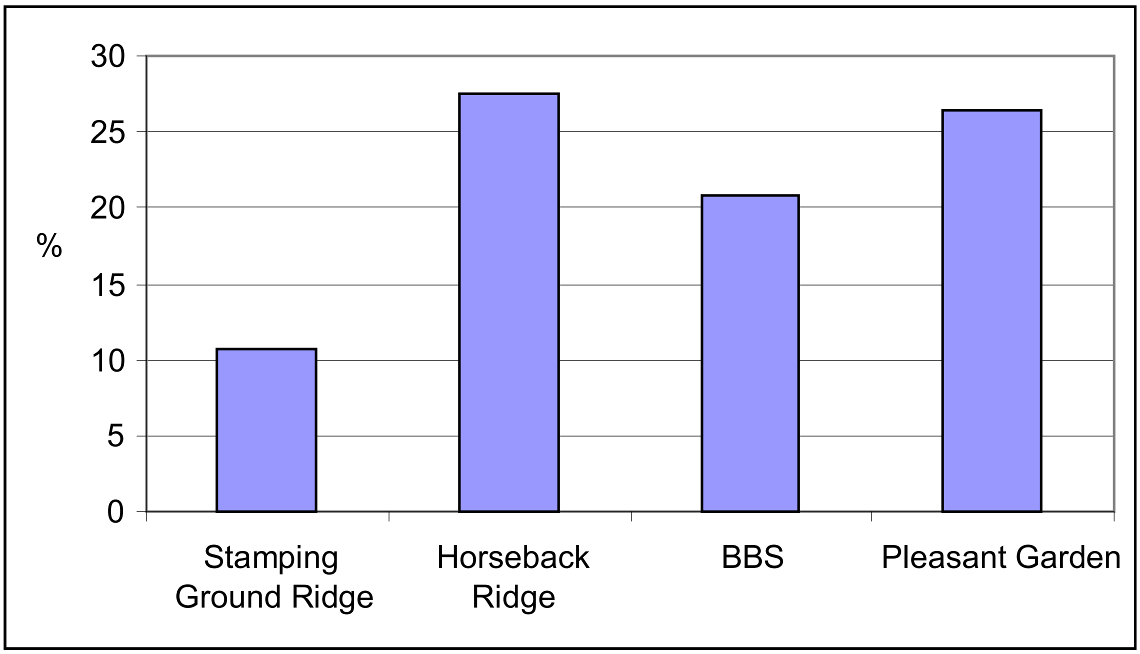

Figure 35 Graph Showing Percentage of Small Woody Plants that are Tree Species

Table 2 Small Woody Plant Species Frequency Summary of all of the Plots

Species	Stamping Ground Ridge	Horseback Ridge	BBS	Pleasant Garden
Deciduous Species				
Blueberry	25.9%	15.0%	22.3%	6.8%
Fire Cherry	2.8%	4.6%	______	0.5%
Yellow Birch	2.5%	9.2%	0.6%	14.9%
Red Maple	2.8%	3.8%	______	______
Blackberry	0.4%	______	______	______
Sourwood	2.1%	2.5%	1.7%	______
Mountain Ash	______	4.6%	______	0.5%
Moosewood	______	0.8%	______	1.4%
Red Oak	______	______	______	1.8%
Clethra	______	______	______	6.3%
Totals	36.5%	40.5%	24.6%	32.2%
Evergreen Species				
Rhododendron	43.6%	55.8%	52.0%	57.7%
Mountain Laurel	17.7%	1.7%	3.4%	9.0%
Table Mountain Pine	0.4%	______	______	______
Eastern Hemlock	______	1.3%	______	0.5%
Red Spruce	______	0.8%	18.3%	0.9%
Totals	61.7%	59.6%	73.7%	68.1%

Hierarchical Cluster Analysis Results

Below are the results for the hierarchical cluster analysis. Table 3 is the Dissimilarity Matrix of comparisons between each of the plots. Figure 36 is the dendrogram, which show the similarity between each of the plots.

Table 3 Dissimilarity Matrix Comparing the Four Plots

	Squared Euclidean Distance			
Case	1:SGR	2:HBR	3:BBS	4:PG
1:SGR	.000	2860.254	18271.857	18432.277
2:HBR	2860.254	.000	7271.126	8662.186
3:BBS	18271.857	7271.126	.000	5296.070
4:PG	18432.277	8662.186	5296.070	.000

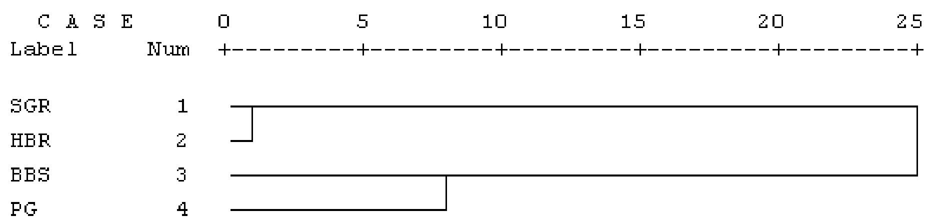

Figure 36. Dendrogram Showing Similarity between Plots

CHAPTER 4

OBSERVATIONS

Territories

On plot number 1, Stamping Ground Ridge, 2 male Magnolia Warblers had territories throughout the entire summer breeding season. There was one other male that could be heard singing in May but left the plot by June. No nests were seen on this plot, nor were any fledglings seen during the breeding season.

On Horseback Ridge there were 2 males with territories present for the entire breeding season. No nests were found on this plot, and no fledglings were seen.

The Breeding Bird Survey plot had 2 males on territories throughout the entire summer breeding season. Fledglings were seen on 3 different occasions on this plot. These young were fed by an adult male Magnolia Warbler. The nests were not found; however, it is certain that the nests were near the fledglings.

Pleasant Garden was home to 3 males with territories throughout the summer. No nests nor fledglings were seen on this plot, although 1 female was seen here.

Males

Male Magnolia Warblers were present on all plots in the first week of May and were heard singing until mid-August. The territorial males were often seen and heard singing on their territories. They often used trees on the plots as perches to sing from, and then would be seen flying into the shrub layer. They worked the inner areas of the trees and shrubs moving quickly in search of insects to feed on. They were often heard singing while they were searching for food. These males, when feeding, rarely sat still, but instead moved quickly from one place to another in search of food. The only time they were noted as sitting still for extended periods of time was when they were singing from a higher perch.

Females

Females were rarely seen during this breeding season. The only plots where females were seen were the Breeding Bird Survey plot and Pleasant Garden. The only time they were noted was when "pishing" noises were made by the researcher to attract the birds. Males never reacted to these "pishing" noises except when fledglings were present on a plot, which means they were probably trying to protect these fledglings.

Fledglings

Fledglings were seen only on the Breeding Bird Survey plot. This plot had a very high density of trees with the highest average DBH of all of the plots (Figures 27 and 28), but still had a dense understory of shrubs. The fledglings were seen in an area of the plot which was a transition zone between the hardwood and Red Spruce forest.

A single fledgling was seen on June 30, July 8, and July 14, and at least 1 more could be heard in the area. The fledglings were also heard on July 23. On the occasions when the young birds were seen, a male Magnolia Warbler was also seen feeding the fledglings.

CHAPTER 5

DISCUSSION

Breeding

Although no nests were found during the duration of this study, significant proof of nesting was established. This was in the form of fledglings that were seen several times on the BBS plot. These fledglings were fed by a male Magnolia Warbler on each occasion that they were seen. So even though no actual nests were found, the presence of fledglings provides solid proof that this species is in fact breeding in Unicoi County, TN on Unaka Mountain. This breeding site, therefore, represents a new breeding bird for the state of Tennessee and a southern extension in the geographical breeding range of the Magnolia Warbler. Although no proof of nesting was found on the other sites, territorial males were present on every plot and a female was seen on Pleasant Garden (as well as on the BBS plot). This means that there is a good chance that there were other nests, but they were just not located. The BBS plot where the fledglings were seen does have several unique aspects when compared to the other sites as is shown below.

Plot Comparisons Between the BBS Plot and the Other Plots

There were some significant differences between the plots on Unaka Mountain, but is the BBS plot, which is where the fledglings were seen, significantly different from the other plots? The large woody plants on the BBS plot are on average larger than the large woody plants on the other plots. The average DBH was largest here at 11.6 cm. Pleasant Garden had the most large woody plants (142) and BBS had the second most

(94), but Pleasant Garden was much less diverse. The BBS and Horseback Ridge plots had the highest diversity and evenness. They both had at least 5 large woody plant species which accounted for at least 10% of the total large woody plants. The Pleasant Garden plots only had one tree species which accounted for at least 10% of the large woody plant species. It was composed of 74.6% Yellow Birch. The plots on Horseback Ridge and BBS had by far the largest percentage of large woody plants composed of evergreen species (36.8% and 34.1% respectively).

The small woody plants on BBS (188 cm) and Pleasant Garden (194) were significantly taller than on the other 2 plots, which means that these plants are probably more old-growth. There were more old-growth Rhododendron present here that were large enough to be counted in the large woody plant layer (12.8 % of plants) than on any other plot. These Rhododendron were taller and thicker than many places on the other plots. The total number of small woody plants which were recorded (This can involve counting a single plant more than once because they were recorded every meter. If the plant was spread out enough, it could be counted more than once.) was the smallest for the BBS plot at 172. Because there were old-growth Rhododendrons here, the largest ones, which were counted with the trees, blocked out many other shrubs from being able to grow. These small woody plants were composed of more evergreen species than any of the other plots at 75%. There were more Red Spruce present in both the large woody plant layer (11.7 %) and in the small woody plant layer (18.3 % - none of the other plots even had 1%) of the BBS plot than on any of the other plots. Because this plot was located on the edge of the Red Spruce Forest, then when there are openings in the habitat (due to falling trees, etc.) then there is a good possibility that young Red Spruce trees will begin to grow here, as is shown by these understory layer percentages. So there were more evergreens in both the large and small woody plant layer on the BBS plots. The percentage of regenerating trees which were small enough to be counted in the small woody plant layer were as follows: Stamping Ground Ridge – 10.6%, Horseback Ridge – 27.6%, BBS – 20.6%, and Pleasant Garden 26.8%. Therefore, Horseback Ridge and Pleasant Garden have the largest number of young, regenerating trees.

Therefore the BBS plot, which is where the fledglings were seen, was unique in that the large woody plants here were larger than on the other plots, the Rhododendron were older and larger, and there were more Red Spruce in both the large and small woody plant layers than on other plots, the evergreen species made up a larger percentage of the total plants than the other plots, the small woody plants, along with Pleasant Garden, were taller than the other plots, as well as several other factors which have been mentioned. The BBS plot is unique in all of these aspects as compared to the other plots.

Habitat Comparisons

One of the principle aspects of this research project is the comparison between plots of the tree and shrub layers. Another foremost aspect of this research is the comparison between these plots and habitat that is found in the historical breeding range of this species. The habitat on Unaka Mountain that this species is occupying during the breeding season is found at the transition between the Red Spruce forest, which is at the higher elevations, and the hardwood forest, which is composed primarily of Yellow Birch. Associated with these forested areas are a dense understory composed of primarily of Catawba Rhododendron, Rosebay Rhododendron, Mountain Laurel, and

Highbush Blueberry. The habitat does not have to be heavily forested, such as on Stamping Ground Ridge, where it resembles a heath bald. This location still has a dense "understory" growth, with several protruding trees. All of the plots had some kind of conifer species of tree present. These are the important features for Magnolia Warbler habitat on Unaka Mountain, Unicoi County, TN.

Thomas Hodgman (October 14, 2003), wildlife biologist and chair of the Maine Partners in Flight Working Group, was contacted on this subject. Maine is a state with a high density of breeding Magnolia Warblers. The chief hardwood trees in this state where Magnolia Warblers are found are American Beech *Fagus grandifolia*, Sugar Maple, and some birch species. The major species of shrubs present there are Speckled Alder *Alnus rugosa*, Winterberry *Ilex verticillata* and Hobblebush *Viburnum anifolium.* The principal species of trees and shrubs present in the state of Maine are, for the most part, entirely different from the species found on Unaka Mountain in east Tennessee. The common feature that these 2 locations share is the general make up, or structure, of the habitat. Both are found in areas that are on the edge of the forest where there is a dense shrub layer with trees interspersed throughout. There are also Red Spruce and Eastern Hemlock present, in which the Magnolia Warbler nests.

There are breeding populations of Magnolia Warblers in West Virginia, and the habitat in this southern Appalachian location is very similar to the habitat on Unaka Mountain. Donna Mitchell (March 31, 2004) of the West Virginia Division of Natural Resources was contacted about Magnolia Warbler habitat in this state. They breed in the Monongahela National Forest at higher altitudes as on Unaka Mountain. They are found in coniferous forest areas and where there is a transition between the coniferous forest and the hardwood forest. The prominent conifer species there is Red Spruce. The major hardwoods there are Red Maple, Yellow Birch, and American Beech. The principle shrubs are Rosebay Rhododendron and Mountain Laurel. These species are very similar to the Unaka Mountain species, but there are minor differences. The structure of this habitat is very similar to Unaka Mountain.

Pat Hisson (May 5, 2004), a naturalist at Blackwater Falls State Park, was also questioned on this subject. This park is located just outside of the Monongahela National Forest and is home to Magnolia Warblers in the breeding season. The habitat here is very similar to that just described and has a mix between evergreen conifers and hardwoods. The conifer trees include Red Spruce and Eastern Hemlock. There are some Balsam Firs in the park, but they are only in 1 small area, are fairly spread out, and are not in an area where Magnolia Warblers have been heard, so this species is more than likely not using these firs. The deciduous trees include Red Maple and Yellow Birch, and the shrubs include both Rododendron and Mountain Laurel. The Magnolia Warblers are found here in areas with conifers present, which also have an understory associated with them. Magnolia Warblers are known to nest in fir, spruce, and hemlocks, all of which are present here.

Magnolia Warblers also breed at several sites in Virginia including Whitetop Mountain and Mt. Rogers. Dr. Phil Shelton (April 6, 2004), retired professor of biology at UVA Wise, was contacted on this subject. The conifer species on Mt. Rogers are Red Spruce and Fraser Fir *Abies fraseri*, but on Whitetop Mountain only Red Spruce are found. The hardwood trees at these locations include Red Maple, Yellow Birch, American Beech, and Mountain Ash. Shrub species are similar to Unaka Mountain.

Whitetop Mountain especially has large amounts of Rhododendron. Another shrub that can be found at these locations is red-berried elder.

Below are some pictures comparing Unaka Mountain (Figure 37), Mt. Rogers (Figure 38), and Blackwater Falls State Park (Figure 39). The first set of pictures are looking at the habitats from a distance. In these pictures the mixture/transition between evergreen conifers and hardwoods can be seen. These are the areas where Magnolia Warblers can often be seen. These pictures were taken in April and May before the deciduous trees had fully developed new leaves, so a contrast can be seen between evergreen and deciduous.

Figure 37 Red Spruce and Deciduous Trees on Unaka Mountain

Figure 38 Spruce, Fir, and Deciduous Trees on Mt. Rogers

Figure 39 Spruce, Hemlock and Deciduous Trees at Blackwater Falls State Park

The next set of pictures is of the habitat on a smaller scale. The pictures are closer so that the understory becomes apparent. The Unaka Mountain picture (Figure 40) shows the Red Spruce mixed in with hardwoods with a thick layer of Rhododendron present. The Mt. Rogers picture (Figure 41) shows fir and spruce mixed with evergreens. Young, small conifers can be seen at the lowest layers in this patch of trees, which represent the understory. The Blackwater Falls picture (Figure 42) clearly shows the thick understory of Rhododendron.

Figure 40 Rhododendron Understory on Unaka Mountain

Figure 41 Young Evergreens in Understory on Mt. Rogers

Figure 42 Rhododendron Understory at Blackwater Falls

The last set of pictures were taken very close to the habitat. Here the structure of the habitat can be seen more clearly, with the understory being shown in more detail. The Unaka Mountain picture (Figure 43) the Rhododendron are shown to be very thick as an understory. Here they are mixed in with hardwoods, and the Red Spruce can be seen in the background. In the Mt. Rogers picture (Figure 44), the young spruce and fir trees can be seen, which make up the understory at this particular location. For the Blackwater Falls picture (Figure 45), the Rhododendron can clearly be seen as an understory for the surrounding hardwoods and evergreen conifers. There are several Eastern Hemlocks present in this picture.

Figure 43 Rhododendron Mixed with Deciduous Trees on Unaka Mountain

Figure 44 Young, Low-growing Spruce and Fir in the Understory on Mt. Rogers

Figure 45 Rhododendrons as Understory for Evergreens and Deciduous Trees at

Blackwater Falls

The same general vegetation structure of either spruce, fir, or hemlock mixed with hardwood species with a thick understory is what is critical for this species to be found in any specific habitat. The previous pictures show that each of these locations have habitats with a very similar overall structure. This structure is necessary for the breeding habitat of the Magnolia Warbler. There are other areas in the southern Appalachians that have a similar habitat, and if Magnolia Warblers are not present currently at these locations, then there is a possibility that they could be found there in the future. One of these possible Magnolia Warbler habitats can be found on Roan Mountain, TN/NC, were Magnolias have been observed on a few separate occasions in the past during the breeding season. They have not, however, been recorded on a consistent basis. If the population on Unaka Mountain begins to grow, it could possibly serve as a source population for other suitable habitats in the area, such as Roan Mountain. The only areas in Northeast Tennessee that have this suitable habitat structure are found at the high elevations, where there is a transition zone between the hardwood and Red Spruce forests. If this population on Unaka Mountain continues to grow, and more and more adults are breeding, then some individuals may begin to migrate to other suitable habitats in nearby areas.

Hierarchical Cluster Analysis Discussion

The following results are from the hierarchical cluster analysis of the data from the individual plots. Table 1 is the dissimilarity matrix. Here each plot is compared to each other plot. The larger the number is, the less related the 2 plots are. Therefore, Stamping Ground Ridge and Horseback Ridge are the most closely related. Pleasant Garden is somewhat related to the BBS, but not to any of the others. The BBS plot is also fairly related to Horseback Ridge but not extremely closely and the BBS plot is not closely related to Stamping Ground Ridge. Table 2 is the dendrogram, and here is a visual example of what the dissimilarity matrix predicted. Here it is shown that Stamping Ground Ridge is similar only to Horseback Ridge. This similarity comes from the different input measurements. These 2 plots had the lowest total number of trees (38 and 60 respectively), the shortest average understory height (128.2 cm and 154.2 cm respectively), and both had few Red Spruce present. Pleasant Garden is similar only to the BBS plot because they both had the highest total number of trees present (142 and 94 respectively) and they both had the highest average height of the understory layer (194.1 cm and 187.6 cm). From these tables it can be shown that the BBS plot (and the Horseback Ridge Plot to some degree) is a transition between the heath balds of Stamping Ground Ridge and the Red Spruce/Northern Hardwood forest of Pleasant Garden. This transition may be the reason that fledglings were found on this plot and on no others. From this analysis, it has been shown that the BBS plot is quite different from Stamping Ground Ridge and Horseback Ridge. It is not closely related to Pleasant Garden, but as is shown in the dendrogram, it is not as similar as Stamping Ground Ridge is to Horseback Ridge.

So what does all of this mean for this project? I know that breeding occurred on the BBS plot because this is where the fledglings were seen. But there is a good possibility that there were more fledglings on other plots, also, because there were at least 2 territorial males on each plot. Also a female was spotted on the Pleasant Garden plot. The fact that these birds where on the other plots means that there is a good chance that there were other young birds. But because the BBS plot is quite different from the other plots, then these variables might make it more likely to find breeding Magnolia Warblers on this plot. The differences that were noted earlier may indicate a habitat that is just a little better for the nesting of this species. These differences include a large number of trees, more Red Spruce, a tall understory, older large woody plants (larger DBH), and older small woody plants. Therefore, the differences in this BBS plot have made it more likely to find breeding Magnolia Warblers there, and these are factors that can be used to locate other possible breeding sites.

Ecological Considerations

There are several ecological considerations to reflect on when studying this population of Magnolia Warblers on Unaka Mountain. Some examples are what their chances of local extinction at this location are and what their chances of populating other nearby suitable locations are.

This warbler population can be considered to be populating a habitat island because the only suitable habitat for this species is at the higher elevations. These birds are isolated at the top of the mountain, and they are constrained to the area of the mountain that contains suitable habitat for this species. Much is presently known about the ecology of islands, and this knowledge can be used to analyze the Unaka Mountain population of Magnolia Warblers.

MacArthur and Wilson (1963 and 1967) developed the equilibrium theory of insular biogeography. There are 2 principle factors that determine the species richness of any island. They are colonizations, which add to the species richness, and extinction, which decreases the species richness. After their studies of individual islands, MacArthur and Wilson stated that there are 2 major properties of an island that will determine the rate of these 2 factors, which are the size, or area, of the island and the distance from the island to the mainland, or a source of a new colonizing species. The extinction rate increases as the size of the island decreases. One reason for this is that smaller islands can support a smaller total population size because of limited resources. Because these populations are smaller, there is a greater chance that the population could become extinct because of situations such as chance sex ratios (all male or all female) or environmental catastrophes, such as hurricanes or fires. Therefore, the smaller an island is the more probable that a population will become extinct. The extinction rate also increases the farther an island is from the mainland, which can serve as a source population of replacement individuals if the insular individuals begin to die off. The colonization rate of an island increases as the size of an island increases. This is because as the island increases in size, a greater amount of resources become available for use by a species. Therefore, larger islands can support more organisms. The colonization rate of an island also increases with a decrease in the distance between the mainland source population and the island. This is simply because as the distance to an island increases, the probability of finding this island by random chance alone increases.

Magnolia Warblers have successfully colonized the "island" of Unaka Mountain. Any type of colonization involves both dispersal to the new location and establishment there. The "island" of Unaka Mountain is tiny when compared to the "mainland" of this species' historical breeding range. It is also about 60 miles from the closest source population on Whitetop Mountain, VA. These populations are smaller and more scattered at the edges of the range of this species. Both of these facts point toward a high probability of extinction of the Magnolia Warbler population at this northeastern Tennessee location. This likelihood of extinction is decreased, however, by the fact that many Magnolia Warblers migrate through the Unaka Mountain area each fall and spring because it is between their historical breeding and wintering grounds. Therefore, this site is restricted by its small size and distance to source populations but becomes somewhat less constricted by the fact that many Magnolias pass through the Unaka Mountain area during migration. More research on the total area of Magnolia Warbler habitat use at this location and the total area of suitable habitat here could give more specific probabilities of survival and possible dispersal of this species from Unaka Mountain to new locations.

If the population can grow large enough at this location, it could become a small source population to other nearby "islands" with similar suitable habitat. One such example is nearby Roan Mountain TN/NC, which has been home to sporadic Magnolia Warbler sightings during past breeding seasons.

This research gives basic information on the type of habitat that Magnolia Warblers are using on Unaka Mountain. This information is very important in the conservation of this population of new breeding birds in the state of Tennessee. If the habitat that these birds are currently using is conserved, then with future research, it may become more clearly understood how likely this species is to stay at this location in Tennessee, and how likely it is to spread to new breeding locations.

Summary

To summarize all of this research, the important aspects of a Magnolia Warbler's habitat are now more clearly understood. There must be evergreen conifers present. These can include species of spruce, fir, or hemlock. These species are important for the nesting of the Magnolia Warbler. These birds are also often found in an area that is a transition between conifer and hardwood forest. Most times the trees are sparse and are associated with a thick understory layer composed of both shrubs and young trees. These habitats are mostly found at the higher elevations in the southern Appalachians. If this habitat exists at a certain location, then it is a prime habitat to find nesting Magnolia Warblers during the breeding season. This species has been extending its southern breeding range recently and should continue to show up in higher and higher numbers at these prime habitat southern Appalachian locations.

REFERENCES

Bent, A. C. 1963. Life histories of North American wood warblers. Dover Publications, New York.

Cairns, J. S. 1889. The summer birds of Buncombe County, North Carolina. Ornithologist and Oologist 14: 17-23.

Chapman, F. M. 1968. The warblers of North America. Dover Publications, New York.

Cumming, E. E., Diamond, A. W. 2002. Songbird community composition versus forest rotation age in Saskatchewan boreal mixedwood forest. Canadian Field Naturalist 116(1):69-75.

Davis, R. 2001. Briefs for the files. The Chat 65(1):42-43.

Hall, G. A. 1994. Magnolia Warbler (*Dendroica magnolia*). *In* The birds of North America, No. 136 (A. Poole and F. Gill, Eds.). Piladelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologist' Union.

Hisson, P. 2004. Naturalist at Blackwater Falls State Park Davis, WV. Personal Communication. May 5, 2004.

Hobson, K. A., Bayne, E. 2000. The affects of stand age on avian communities in aspen-dominated forests of central Saskatchewan, Canada. Forest Ecology and Management 136(1-3):121-134.

Hodgman, T. 2003. Maine Department of Inland Fisheries and Wildlife. Personal Communication. October 14, 2003.

Knight, R. L. 1994. The birds of northeast Tennessee. Richard L. Knight, Johnson City, TN.

Lewis, R. 2000. The season. The Migrant 71(4):123.

MacArthur, R. H., Wilson, E. O. 1963. An equilibrium theory of insular zoogeography. Evolution 17:373-87.

MacArthur, R. H., Wilson, E. O. 1967. The theory of island biogeography. Princeton University Press, Princeton, NJ.

Mitchell, D. 2004. West Virginia Division of Natural Resources. Personal Communication. March 31, 2004.

Mitchell, J. M. 1999. Habitat relationships of five northern bird species breeding in hemlock ravines in Ohio, USA. Natural Areas Journal 19(1):3-11.

Shelton, P. 2004. Retired Professor of Biology at University of Virginia College at Wise. Personal Communication. April 6, 2004.

Trently, A. 2003. Seasonal Ecologist. Southern Appalachian Highlands Conservancy. Personal Communication. May 13, 2003.

Unicoi Quadrangle. 1939. United States Geological Survey Topographical Map. Washington D.C.: US Geological Survey.

United States Geological Survey. 2002. Magnolia Warbler *Dendroica magnolia* summer distribution map. Accessed January 20, 2003. [http://www.mbr-pwrc.usgs.gov/bbs/htm96/map617/ra6570.html.]

APPENDICES

Appendix A. Abbreviations

The following abbreviations were used to show the results:

BB – Highbush Blueberry *Vaccinium corymbosum*

BL – Alleghany Blackberry *Rubus allegheniensis*

CL – Clethra *Clethra anifolia*

EH – Eastern Hemlock *Tsuga canadensis*

EP – Eastern White Pine *Pinus strobus*

FC – Fire Cherry or Pin Cherry *Prunus pensylvanica*

HH – Eastern Hophornbeam *Ostrya virginiana*

MA – American Mountain Ash *Sorbus americana*

ML – Mountain Laurel *Kalmia latifolia*

MW – Moosewood or Striped Maple *Acer pensylvanicum*

RH – Rhododendron both Catawba *Rhododendron catawbiense* and Rosebay *Rhododendron maximum*

RM – Red Maple *Acer rubrum*

RO – Red Oak or Northern Red Oak *Quercus rubra*

RS – Red Spruce *Picea rubens*

SM – Sugar Maple *Acer saccharum*

SW – Sourwood *Oxydendrum arboreum*

TP – Table Mountain Pine *Pinus pungens*

WA – White Ash *Fraxinus americana*

WO – White Oak *Quercus alba*

YB – Yellow Birch *Betula alleghaniensis*

Appendix B. Stamping Ground Ridge Subplot 1 Results

Table 4 Stamping Ground Ridge Subplot 1 Trees

TP – 11.0, 11.8, 15.6, 13.0
SW – 10.4, 6.6, 6.6, 10.5, 9.7, 5.0, 6.8, 7.2
MA – 7.6, 5.2
RM – 11.4, 9.8, 7.6
YB – 9.2, 7.2
FC – 5.8, 8.2, 6.4

Table 5 Stamping Ground Ridge Subplot 1 Line 1 Shrubs

1. 0
2. 0
3. BB – 69.8, RH – 102.0
4. RH – 104.8, FC – 152.4
5. 0
6. BB – 83.2
7. RH – 102.0
8. BB – 69.1, RH – 174.2
9. BB – 137.0
10. BB – 173.2, RH – 195.3
11. RH – 165.2, FC – 203.7
12. RH – 133.6, BB – 162.6
13. RH – 101.3, BB – 141.7
14. RH – 207.1, BB – 257.0
15. RH – 229.3
16. RH – 214.0
17. RH – 282.5
18. RH – 201.7, YB – 309.1
19. RH – 113.6, YB – 365.7
20. RH – 150.8, YB – 262.6

Table 6 Stamping Ground Ridge Subplot 1 Line 2 Shrubs

1. BB – 83.3, RH – 107.1
2. BB – 59.0, RH – 104.7
3. BB – 35.2, ML – 119.0
4. BB – 77.3
5. BB – 47.3
6. ML – 117.0
7. BB – 83.0, ML – 109.6
8. BB – 132.2
9. BB – 123.7
10. RH – 125.5, BB – 167.2
11. RH – 163.7
12. BB – 49.9, RH – 175.0, FC – 262.1
13. BB – 84.0, ML – 113.1, RH – 137.0
14. ML – 66.4
15. BB – 102.7
16. RH – 165.2, ML – 195.8
17. BB – 166.3, RH – 122.8, ML – 203.6
18. ML – 122.6, RH – 187.3
19. RH – 117.3
20. 0

Table 7 Stamping Ground Ridge Subplot 1 Line 3 Shrubs

1. 0
2. RH – 132.5
3. BB – 32.2, RH – 137.3
4. BB – 47.7
5. BB – 32.1, RH – 73.0
6. RH – 85.5
7. BB – 42.0, RH – 67.3
8. RH – 43.7, BB – 30.3
9. BB – 27.2, RH – 48.6, RM – 273.7
10. RM – 204.6
11. RH – 42.3, RM – 207.0
12. RH – 68.3
13. ML – 40.1, RH – 79.2
14. ML – 49.8, RH – 83.9
15. RH – 42.7, ML – 63.3
16. BB – 24.3, ML – 67.4
17. BB – 29.3
18. BB – 38.7, ML – 42.3, RH – 67.4
19. RH – 83.7
20. RH – 127.9

Appendix C. Stamping Ground Ridge Subplot 2 Results

Table 8 Stamping Ground Ridge Subplot 2 Trees

TP – 17.2, 7.1
FC – 5.0, 10.7
SW – 9.2, 5.6

Table 9 Stamping Ground Ridge Subplot 2 Line 1 Shrubs

1. 0
2. BL – 8.3
3. RH – 176.3
4. BB – 57.0, RH – 163.0
5. ML – 26.3, BB – 89.6, RH – 131.6
6. BB – 56.0, RH – 93.1
7. BB – 33.0
8. RH – 73.9
9. RH – 120.2
10. RH – 92.6
11. 0
12. ML – 117.4
13. ML – 103.0
14. RH – 92.7
15. RH – 121.6
16. ML – 26.0
17. SW – 42.7, RH – 62.3
18. SW – 123.2, RH – 183.1
19. BB – 98.2, RH – 172.3
20. BB – 73.3, SW – 131.0, RH – 160.7

Table 10 Stamping Ground Ridge Subplot 2 Line 2 Shrubs

1. 0
2. BB – 55.0, RH – 92.3
3. RH – 173.7
4. 0
5. BB – 25.0, RH – 154.2
6. ML – 19.2, BB – 38.7
7. BB – 33.1, ML – 112.0
8. BB – 32.0
9. BB – 24.8, RH – 130.2
10. BB – 32.8, ML – 49.7
11. 0
12. RH – 93.5, SW – 88.3
13. BB – 41.0, ML – 120.9, RH – 133.7
14. BB – 57.6, RH – 127.1
15. ML – 79.8, BB – 93.2
16. RH – 99.6, ML – 121.0
17. BB – 60.3, ML – 89.2
18. 0
19. BB – 76.0, ML – 88.3, SW – 115.7
20. RH – 104.2, SW – 162.3

Table 11 Stamping Ground Ridge Subplot 2 Line 3 Shrubs

1. RH – 207.3
2. ML – 41.7, BB – 63.7, RH – 180.2
3. BB – 82.9, RH – 84.7
4. RH – 80.1
5. BB – 63.5
6. RH – 87.9, ML – 93.2
7. ML – 106.5
8. RH – 68.7
9. RH – 95.2
10. 0
11. 0
12. FC – 232.7
13. RH – 103.9, FC – 207.3
14. RH – 102.1
15. RH – 113.8
16. RH – 129.2
17. RH – 117.0
18. ML – 62.0, RH – 93.5
19. ML – 75.7
20. ML – 48.9

Appendix D. Stamping Ground Ridge Subplot 3 Results

Table 12 Stamping Ground Ridge Subplot 3 Trees

TP – 10.1
EP – 5.3
RM – 6.2, 8.2
FC – 5.2, 11.6
YB – 7.3
SW – 5.7, 6.0

Table 13 Stamping Ground Ridge Subplot 3 Line 1 Shrubs

1. ML – 28.0
2. BB – 24.2, RH – 147.3
3. VP – 106.3, RH – 116.7
4. BB – 106.1, ML – 125.3
5. BB – 120.7
6. BB – 105.6
7. BB – 96.0, ML – 147.3
8. BB – 116.7, RH – 189.7
9. RH – 197.3
10. BB – 83.0, RH – 132.7
11. BB – 84.0
12. RH – 186.9
13. RH – 122.3
14. BB – 88.8, RH – 137.7, RM – 267.3
15. RH – 140.1, RM – 288.1
16. BB – 114.0, RH – 146.8
17. RH – 85.0, ML – 152.8
18. ML – 118.1, RH – 162.3
19. ML – 114.0
20. ML – 122.9, RH – 144.4, RM – 263.5

Table 14 Stamping Ground Ridge Subplot 3 Line 2 Shrubs

1. RH – 182.4, BB – 197.3
2. RH – 145.0, BB – 170.3
3. RH – 232.9, YB – 245.0
4. ML – 58.0, RH – 132.7, BB – 202.0
5. ML – 106.2, YB – 211.0
6. RH – 200.2, BB – 213.7
7. BB – 252.1
8. RH – 215.5
9. RH – 205.3
10. RH – 232.9
11. RH – 113.0, BB – 115.6
12. BB – 150.7, RH – 190.0
13. RH – 227.3
14. RH – 293.1
15. RH – 245.0
16. RH – 218.3, ML – 235.0
17. RH – 251.0, ML – 257.3
18. RH – 218.7, YB – 290.3
19. RH – 114.3, ML – 237.3
20. RH – 150.1, ML – 182.8

Table 15 Stamping Ground Ridge Subplot 3 Line 3 Shrubs

1. BB – 32.7
2. BB – 38.1, RM – 141.0
3. ML – 82.3
4. RH – 103.2, RM – 182.3
5. ML – 53.2, RH – 157.2
6. RH – 236.1
7. FC – 113.7, RH – 202.3
8. FC – 121.3
9. RH – 130.2, FC – 273.1
10. RH – 137.2, ML – 207.0
11. RH – 160.2, ML – 178.1
12. ML – 118.3, RH – 97.7
13. RH – 202.7
14. BB – 129.3, RH 239.1
15. RH – 187.3
16. RH – 118.9, ML – 123.7
17. RH – 109.7
18. RH – 72.3, BB – 209.3
19. 0
20. RH – 119.2, BB – 173.3

Appendix E. Horseback Ridge Subplot 1 Results

Table 16 Horseback Ridge Subplot 1 Trees

FC – 5.8, 6.2, 7.7
EH – 11.7, 12.8, 15.2, 18.5,
RM – 6.1
TP – 6.8
YB – 5.0, 5.2, 5.2, 5.7, 6.7, 14.1
SW – 6.6
RS – 5.0

Table 17 Horseback Ridge Subplot 1 Line 1 Shrubs

1. 0
2. FC – 41.0
3. BB – 68.2, RH – 113.0
4. 0
5. RH – 92.1, BB – 137.3
6. ML – 58.3, RH – 42.7
7. RH – 112.2
8. RH – 94.2, BB – 135.9, FC – 198.6
9. RH – 182.7, MA – 233.0
10. RH – 185.5, MA – 227.3
11. RH – 141.2, MA – 263.2
12. RM – 202.0
13. RH – 218.7
14. RH – 247.3, MA – 253.7
15. RH – 230.9, MA – 249.2
16. RH – 237.1, RM – 352.0
17. RH – 245.3, RM – 362.0
18. RM – 263.3
19. RH – 227.3
20. RH – 220.4

Table 18 Horseback Ridge Subplot 1 Line 2 Shrubs

1. RH – 102.6
2. 0
3. BB – 56.9, RH – 66.2
4. RH – 84.0
5. BB – 69.2
6. RH – 42.0
7. RH – 118.0
8. RH – 146.3, MW – 161.3
9. RH – 152.3, BB – 248.7
10. BB – 230.8
11. RH – 181.0
12. RH – 195.2
13. RH – 218.9, YB – 230.7
14. RH – 250.8
15. RH – 273.4
16. RH – 247.9
17. RH – 213.7
18. 0
19. BB – 212.3
20. RH – 198.3, YB – 307.3

Table 19 Horseback Ridge Subplot 1 Line 3 Shrubs

1. BB – 78.0
2. RH – 79.3, BB – 93.7
3. BB – 56.0, RH – 95.3
4. BB – 49.3, RM – 98.7
5. BB – 83.0, RM – 132.7
6. RH – 118.7
7. 0
8. RH – 49.3
9. RH – 53.7, BB – 102.0
10. BB – 114.9
11. 0
12. RH – 127.3
13. RH – 72.7, SW – 247.3
14. RH – 87.9, SW – 213.9
15. SW – 203.7
16. YB – 213.7
17. YB – 227.3
18. RH – 72.3, YB – 205.8
19. RH – 67.3
20. RH – 97.0

Appendix F. Horseback Ridge Subplot 2 Results

Table 20 Horseback Ridge Subplot 2 Trees

RM – 5.3, 5.8, 6.7, 7.5, 8.8, 10.0
YB – 5.3, 5.4, 5.9, 6.2, 6.8, 6.9, 7.1, 7.2, 7.5, 12.2
EH – 5.6, 13.7, 16.3
SW – 5.4, 6.3, 6.8
MA – 6.8, 14.9
RS – 8.4, 31.1
TP – 7.8, 10.9

Table 21 Horseback Ridge Subplot 2 Line 1 Shrubs

1. 0
2. 0
3. BB – 25.1, RH – 104.0
4. 0
5. BB – 88.3, RH – 123.2
6. BB – 121.6, SW – 211.9
7. BB – 90.1, SW – 203.7, YB – 203.9
8. RH – 292.8
9. RH – 235.6
10. RH – 275.3
11. RH – 247.7
12. RH – 272.1
13. 0
14. 0
15. YB – 185.9
16. RH – 121.6
17. RH – 94.0, YB – 221.6
18. YB – 198.3, RH – 283.1
19. RH – 141.8
20. RH – 72.1, YB – 243.7

Table 22 Horseback Ridge Subplot 2 Line 2 Shrubs

1. 0
2. MW – 48.1, MA – 123.1
3. RH – 130.3, MA – 203.1
4. BB – 85.1, RH – 135.0
5. YB – 107.0
6. RH – 43.0, BB – 67.3
7. RH – 125.2
8. RH – 148.0, RM – 166.1
9. RH – 165.2
10. RH – 134.2, YB – 202.7
11. RH – 123.8, YB – 247.3
12. 0
13. RH – 138.5, YB – 208.7
14. RM – 249.8, RH – 265.3
15. RH – 245.6, BB – 258.9
16. RH – 332.8
17. RH – 248.3
18. YB – 252.4, RH – 278.1
19. RH – 273.9
20. RH – 244.6

Table 23 Horseback Ridge Subplot 2 Line 3 Shrubs

1. 0
2. 0
3. YB – 64.2
4. RH – 106.0, YB – 152.3
5. RH – 57.2, FC – 147.3
6. RH – 167.8
7. RH – 71.1, YB – 172.9
8. RH – 51.7, YB – 203.4
9. RH – 100.3
10. RH – 212.6
11. RH – 237.5, YB – 249.1
12. RH – 251.3
13. YB – 152.4, RH – 263.9
14. RH – 170.7
15. RH – 172.5
16. RH – 273.0
17. YB – 121.6, RH – 257.3
18. RH – 219.8
19. RH – 223.2
20. RH – 212.1

Appendix G. Horseback Ridge Subplot 3 Results

Table 24 Horseback Ridge Subplot 3 Trees

TP – 9.8, 10.7, 11.1, 13.9
EP – 7.3
EH – 6.8, 9.4, 14.3
FC – 5.0, 5.6, 11.5
RM – 5.5, 5.7, 6.0

Table 25 Horseback Ridge Subplot 3 Line 1 Shrubs

1. 0
2. RH – 124.2
3. RH – 121.6
4. BB – 108.7, RH – 164.5
5. RH – 147.2, SW – 214.8
6. RH – 129.3
7. EH – 66.0, RH – 195.5
8. RH – 237.2
9. RS – 18.0, RH – 172.5
10. RH – 154.9
11. BB – 113.6, RH – 135.3
12. BB – 81.2, RH – 118.1
13. RH – 101.9, MA – 137.0
14. RH – 114.2
15. RH – 146.9, ML – 204.7
16. RH – 135.0
17. RH – 69.2, FC – 198.2
18. RH – 184.6, FC – 187.2
19. RH – 163.5
20. RH – 173.1

Table 26 Horseback Ridge Subplot 3 Line 2 Shrubs

1. BB – 75.2
2. RH – 119.8
3. BB – 73.5
4. BB – 69.2
5. BB – 44.8, FC – 95.0
6. BB – 83.0, RH – 115.7
7. RH – 107.2, MA – 173.9
8. MA – 81.2, RH – 114.3
9. 0
10. BB – 105.1, RH – 124.3
11. BB – 117.0, RH – 162.2
12. BB – 101.2, RH – 189.3, MA – 204.3
13. 0
14. 0
15. RH – 198.3
16. RH – 185.7
17. RH – 50.0
18. RH – 207.0
19. RH – 183.9
20. RH – 96.0, RM – 262.1

Table 27 Horseback Ridge Subplot 3 Line 3 Shrubs

1. 0
2. 0
3. FC – 121.6, BB – 145.0
4. RH – 70.1, BB – 133.3
5. RH – 137.9
6. RH – 122.7
7. RH – 121.6
8. BB – 41.0, RH – 126.2
9. RH – 48.1
10. ML – 90.7
11. ML – 83.8, RH – 121.4
12. RH – 91.2
13. RS – 20.0, RH – 98.2, FC – 147.8
14. FC – 57.2, RH – 103.7
15. RH – 192.6
16. RH – 173.7
17. RH – 147.3
18. RH – 108.0, FC – 189.2
19. RH – 55.3, EH – 82.3
20. RH – 137.7, EH – 143.5, SW – 149.2

Appendix H. BBS Subplot 1 Results

Table 28 BBS Subplot 1 Trees

RS – 9.3, 10.9
YB – 7.9, 9.6, 11.3, 12.0, 13.0, 16.4, 25.1
EP – 28.7
FC – 15.5, 12.5
RH – 5.0, 5.0, 5.3, 5.8, 7.2
MA – 16.2, 22.5
SW – 7.8, 8.1, 9.2
RM – 6.2, 6.2, 10.1, 10.2, 12.9

Table 29 BBS Subplot 1 Line 1 Shrubs

1. RH – 106.2
2. RH – 263.7
3. RH – 273.5
4. RH – 201.3, YB – 322.7
5. RH – 26.3, RS – 108.0
6. RH – 121.6, RH – 152.1
7. RH – 257.3
8. RH – 247.9
9. RH – 187.0
10. RH – 139.5
11. RH – 231.8
12. RH – 303.6
13. RH – 258.8
14. RH – 265.3
15. RH – 260.1
16. RH – 272.0
17. RH – 298.4
18. RH – 207.2
19. RH – 223.2
20. RH – 230.6

Table 30 BBS Subplot 1 Line 2 Shrubs

1. RH – 218.4
2. RH – 230.3
3. RH – 252.1
4. RH – 237.5
5. 0
6. BB – 207.3
7. 0
8. RH – 110.8
9. RH – 118.2
10. RS – 110.1, BB – 218.2
11. RS – 119.0
12. RS – 32.2
13. RH – 120.2
14. RH – 137.2, SW – 141.3
15. RH – 183.0, SW – 191.7
16. RH – 202.0, SW – 241.3
17. RH – 218.9, BB – 220.9
18. RH – 172.0
19. RH – 225.3
20. RH – 247.8

Table 31 BBS Subplot 1 Line 3 Shrubs

1. RH – 265.3
2. RH – 242.9
3. RS – 83.7, RH – 239.2
4. RH – 208.3, BB – 245 .1
5. RH – 187.9
6. 0
7. RS – 41.1
8. BB – 149.1
9. 0
10. RS – 91.0, RH – 153.7
11. RS – 54.2, RH – 163.9
12. RH – 127.2
13. 0
14. RH – 41.2
15. 0
16. RH – 103.6
17. RH – 238.4
18. RH – 263.7
19. RH – 222.1
20. RH – 218.4

Appendix I. BBS Subplot 2 Results

Table 32 BBS Subplot 2 Trees

RM – 5.0, 6.5, 6.6, 7.7, 9.2, 16.8
RH – 5.3, 5.6, 6.4, 7.8, 8.8, 9.9
RS – 40.1
SW – 8.5, 8.6, 8.8, 9.5, 11.3, 13.1
YB – 8.4, 8.9, 12.5, 20.2, 20.3
FC – 9.3, 12.2, 16.7, 16.9
EH – 9.2, 14.1, 15.0, 15.4, 17.8
HH – 16.7, 16.9, 9.3, 12.2

Table 33 BBS Subplot 2 Line 1 Shrubs

1. RH – 180.0
2. RH – 220.2
3. 0
4. 0
5. RH – 162.3
6. RH – 205.7
7. RH – 240.8
8. RH – 261.0
9. RH – 257.1
10. RH – 283.1
11. RH – 337.9
12. RH – 237.0
13. RS – 9.8
14. BB – 177.2
15. BB – 258.9
16. 0
17. RH – 139.6
18. RH – 218.1
19. RH – 231.1
20. RH – 237.3

Table 34 BBS Subplot 2 Line 2 Shrubs

1. RH – 229.1
2. 0
3. 0
4. 0
5. 0
6. RH – 98.8
7. RH – 231.2
8. RH – 269.0
9. RH – 273.1
10. RH – 342.1
11. BB – 261.8, RH – 291.3
12. BB – 322.7
13. 0
14. 0
15. 0
16. RS – 63.8
17. 0
18. BB – 297.1
19. BB – 304.7
20. RS – 56.1

Table 35 BBS Subplot 2 Line 3 Shrubs

1. RH – 166.9
2. RH – 200.7
3. RH – 302.2
4. RH – 326.9
5. RH – 256.0
6. RH – 201.3
7. RH – 192.3
8. 0
9. 0
10. RS – 127.1
11. 0
12. 0
13. 0
14. 0
15. RS – 21.1
16. 0
17. 0
18. BB – 218.1
19. RH – 47.2, BB – 238.2
20. RH – 76.0, RS – 85.0, BB – 222.4

Appendix J. BBS Subplot 3 Results

Table 36 BBS Subplot 3 Trees

EH – 16.4, 21.8, 27.2
YB – 6.2, 8.3, 10.2, 16.3, 17.5, 18.1, 19.3, 20.0, 31.2
SW – 6.7, 7.8, 8.8, 9.2, 9.5, 9.5, 10.5, 11.7
RS – 7.1, 8.3, 9.8, 14.9, 15.2, 17.2, 19.8, 23.2
RM – 5.2, 6.1, 6.3, 6.3, 8.1
RH – 5.6

Table 37 BBS Subplot 3 Line 1 Shrubs

1. 0
2. 0
3. RS – 19.0, BB – 203.1
4. 0
5. RS – 52.1, BB – 222.4
6. RS – 31.8
7. RS – 26.1
8. 0
9. 0
10. RS – 117.8
11. RS – 74.9
12. 0
13. RS – 53.0
14. RS – 29.9
15. 0
16. 0
17. RS – 16.9
18. RS – 92.7, RH – 224.7
19. RH – 271.8
20. RH – 248.3

Table 38 BBS Subplot 3 Line 2 Shrubs

1. 0
2. 0
3. BB – 298.2
4. RH – 101.0, BB – 263.7
5. RH – 137.2
6. BB – 163.2
7. 0
8. RS – 50.3
9. RS – 27.1, BB – 251.8
10. BB – 310.2
11. BB – 169.7
12. RS – 162.1, BB – 169.8
13. BB – 177.2
14. BB – 186.9
15. Bb – 137.1
16. 0
17. RS – 175.5
18. RS – 199.9
19. RH – 152.2, BB – 190.8
20. RH – 187.2, BB – 235.4

Table 39 BBS Subplot 3 Line 3 Shrubs

1. BB – 251.7
2. BB – 243.2
3. 0
4. RH – 203.9
5. RH – 267.0
6. RH – 248.9
7. RH – 261.8
8. RH – 253.3, BB – 271.8
9. RH – 227.0, ML – 239.4, BB – 258.2
10. ML – 147.5, BB – 153.9
11. BB – 342.5
12. BB – 210.0
13. ML – 115.9, BB – 259.2
14. ML – 75.1, BB – 268.1
15. ML – 142.7, BB – 202.2
16. ML – 135.2, BB – 159.2
17. RS – 15.3
18. 0
19. 0
20. RS – 25.3

Appendix K. Pleasant Garden Subplot 1 Results

Table 40 Pleasant Garden Subplot 1 Trees

RM – 5.3, 7.9, 16.7
RS – 9.9, 11.1
YB – 5.0, 5.0, 5.1, 5.1, 5.3, 5.7, 6.0, 6.5, 6.9, 8.0, 10.0, 10.3
MW – 6.4, 7.0, 7.8, 9.8
WA – 11.6
MA – 6.4

Table 41 Pleasant Garden Subplot 1 Line 1 Shrubs

1. FC – 93.0
2. ML – 74.4, YB – 142.3
3. RS – 78.4, RH – 93.8, YB – 163.7
4. RH – 144.1, ML – 178.9
5. RH – 197.3
6. RH – 147.8, ML – 292.3
7. RH – 117.0, ML – 231.5
8. RH – 212.6, ML – 231.7, YB – 249.2
9. RH – 197.3, ML – 200.6
10. RH – 191.0, YB – 247.2
11. RH – 134.0, BB – 257.7
12. RH – 170.3
13. RH – 211.8
14. RH – 214.2
15. RH – 25.1
16. 0
17. 0
18. ML – 123.6
19. ML – 124.7
20. RH – 81.1, ML – 103.2

Table 42 Pleasant Garden Subplot 1 Line 2 Shrubs

1. ML – 54.2
2. EH – 116.2
3. CL – 202.7
4. CL – 226.9
5. CL – 294.2, BB – 297.1
6. BB – 131.8, RH – 132.5, YB – 241.7
7. RH – 70.0, YB – 239.7
8. RO – 155.0, YB – 251.3
9. RO – 146.2, YB – 283.9
10. CL – 221.7, RO – 307.2
11. CL – 204.9, RH – 38.1
12. RH – 53.2
13. RH – 273.1
14. RH – 248.2, CL – 257.3
15. CL – 247.8, RH – 251.7
16. ML – 168.1, RH – 195.3
17. RH – 31.8, ML – 132.7, YB – 313.9
18. RH – 201.6
19. RH – 116.0
20. RH – 97.3, BB – 215.5

Table 43 Pleasant Garden Subplot 1 Line 3 Shrubs

1. BB – 47.9
2. RH – 147.2
3. MW – 123.8, RH – 142.3, YB – 261.3
4. YB – 232.7, RH – 254.8
5. RH – 187.7, YB – 208.1
6. RH – 215.7, YB – 268.1
7. RH – 221.7
8. RH – 259.0, BB – 261.8
9. RH – 124.6, YB – 203.1, CL – 362.7
10. CL – 176.1
11. RH – 217.3
12. RH – 264.1, YB – 267.3
13. RH – 237.8, ML – 257.9, CL – 291.1
14. CL – 112.9, ML – 117.0
15. ML – 42.1
16. CL – 164.7, MA – 259.3
17. YB – 121.6, CL – 194.2
18. NO – 117.0, YB – 127.2
19. ML – 83.4, YB – 172.1
20. RH – 57.3, YB – 192.8

Appendix L. Pleasant Garden Subplot 2 Results

Table 44 Pleasant Garden Subplot 2 Trees

SW – 6.9
YB – 5.1, 5.2, 5.2, 5.5, 5.5, 5.5, 5.7, 5.7, 5.7, 5.9, 6.0, 6.0, 6.2, 6.2, 6.2, 6.3, 6.4, 6.5, 6.7, 6.8, 7.0, 7.0, 7.1, 7.4, 7.4, 7.7, 7.7, 7.8, 7.8, 8.0, 8.0, 8.1, 8.6, 8.9, 8.9, 9.2, 9.5, 9.7, 9.9, 15.6, 21.4
RM – 9.9, 10.1, 14.0, 15.0, 16.8
MW – 5.9, 6.8, 11.7, 13.6
MA – 5.5, 5.9
RH – 5.0
EH – 17.7
SM – 10.8

Table 45 Pleasant Garden Subplot 2 Line 1 Shrubs

1. 0
2. RH – 262.7
3. RH – 234.6
4. RH – 62.9
5. RH – 254.7
6. RH – 152.2
7. 0
8. YB – 315.7, RH – 86.8
9. RH – 10.1, YB – 355.6
10. YB – 358.1
11. YB – 368.-
12. RH – 201.7
13. 0
14. BB – 258.2
15. 0
16. 0
17. RH – 241.5
18. RH – 201.1, ML – 221.6
19. RH – 292.3
20. RH – 310.0

Table 46 Pleasant Garden Subplot 2 Line 2 Shrubs

1. 0
2. RH – 260.2
3. CL – 141.8, RH – 257.0
4. RH – 259.1
5. RH – 267.9
6. RH – 267.5
7. RH – 81.8
8. RH – 241.7
9. RH – 221.3
10. RH – 57.5, YB – 275.7
11. RH – 110.0, YB – 262.3
12. RH – 127.8
13. 0
14. YB – 243.6
15. YB – 215.6, RH – 273.6
16. RH – 145.8
17. RH – 138.5, YB – 257.2
18. RH – 220.1, ML – 255.8
19. RH – 121.6, ML – 249.0
20. RS – 89.2, RH – 252.6

Table 47 Pleasant Garden Subplot 2 Line 3 Shrubs

1. 0
2. 0
3. RH – 284.5
4. RH – 263.7
5. RH – 177.2
6. RH – 122.0
7. RH – 203.1
8. RH – 52.1
9. RH – 71.2, MW 77.1
10. MW – 40.6
11. 0
12. YB – 245.2
13. 0
14. 0
15. 0
16. BB – 239.8
17. YB – 255.0
18. YB – 257.8
19. 0
20. RH – 261.1

Appendix M. Pleasant Garden Subplot 3 Results

Table 48 Pleasant Garden Subplot 3 Trees

YB – 5.0, 5.0, 5.2, 5.3, 5.4, 5.4, 5.5, 6.1, 6.1, 6.2, 6.2, 6.3, 6.5, 6.5, 6.6, 6.8, 6.8, 6.8, 7.0, 7.0, 7.2, 7.2, 7.5, 7.8, 7.9, 8.0, 8.0, 8.1, 8.6, 8.6, 8.7, 9,0, 9.0, 9.1, 9.5, 9.5, 9.5, 9.8, 10.2, 10.4, 10.7, 10.9, 11.3, 11.3, 11.9, 12.1, 12.3, 12.3, 12.9, 14.8, 16.9
WO – 12.4
RH – 5.8, 6.1
FC – 9.2
WA – 5.6
MA – 12.2, 15.4, 16.1, 18.2
SM – 29.0

Table 49 Pleasant Garden Subplot 3 Line 1 Shrubs

1. RH – 348.2
2. RH – 369.0
3. RH – 238.6
4. RH – 245.5
5. BB – 137.1, RH – 207.9
6. 0
7. RH – 76.2
8. RH – 237.1
9. RH – 239.8
10. RH – 322.2
11. RH – 266.0
12. 0
13. RH – 319.7, YB – 325.9
14. RH – 241.5
15. 0
16. RH – 163.2
17. RH – 219.7
18. RH – 213.2
19. RH – 145.2
20. 0

Table 50 Pleasant Garden Subplot 3 Line 2 Shrubs

1. RH – 303.7
2. RH – 313.8
3. RH – 272.9
4. RH – 64.0
5. RH – 352.0
6. RH – 308.7
7. RH – 327.2
8. RH – 298.0
9. RH – 245.3
10. RH – 137.7
11. RH – 153.4
12. RH – 104.6
13. RH – 137.2, YB – 243.1
14. RH – 101.0, YB – 167.9
15. RH – 80.1, BB – 211.7
16. RH – 81.0, BB – 165.0
17. RH – 60.0, BB – 348.9
18. RH – 224.2
19. RH – 98.1
20. ML – 273.4, RH – 288.5

Table 51 Pleasant Garden Subplot 3 Line 3 Shrubs

1. RH – 152.6
2. RH – 54.2, BB – 181.1
3. RH – 88.1
4. RH – 243.6
5. RH – 174.2
6. RH – 107.0
7. RH – 71.3
8. RH – 201.7
9. RH – 136.5
10. 0
11. RH – 205.7
12. RH – 186.0
13. 0
14. RH – 308.9
15. RH – 201.0
16. RH – 184.9
17. RH – 45.1, YB – 199.8
18. RH – 121.6
19. 0
20. RH – 168.0

VITA

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